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Glimpses of the Cosmos

A Mental Autobiography

By Lester F. Ward, LL.D.

Vol. I. Adolescence to Manhood Period, 1858–1871 Age, 16–30

Vol. II. Scientific Career Inaugurated

Vol. III. Dynamic Sociology

GLIMPSES OF THE COSMOS

BY

LESTER F. WARD

COMPRISING HIS MINOR CONTRIBUTIONS NOW REPUBLISHED, TOGETHER WITH BIOGRAPHICAL AND HISTORICAL SKETCHES OF ALL HIS WRITINGS

The writings by which one can live are not the writings which themselves live.—JOHN STUART MILL.

LESTER F. WARD

From a photograph taken when 36 years of age

GLIMPSES OF THE COSMOS

BY

LESTER F. WARD

VOLUME II

PERIOD, 1875–1882. AGE, 34–40

There is a tide in the affairs of men,
Which, taken at the flood, leads on to fortune.

—SHAKESPEARE.

G. P. PUTNAM'S SONS
NEW YORK AND LONDON
The Knickerbocker Press
1913

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The Knickerbocker Press, New York

Prefatory Note

LESTER F. WARD died April 18, 1913. On the evening before his death, Volume I of *Glimpses of the Cosmos* reached him. To those of us who knew, it was pathetic to note the joy with which he received it, the tenderness with which he handled it. Yet we felt he would die content, for in this book he found the realization of his heart's desire. *Glimpses of the Cosmos* was to him the culmination of his intellectual life, the rounding out of his fifty years' search for the truth. In it we see a philosophy in the making.

When, during his illness, the task of proof-reading became too great, he asked me to do the work for him, and I have tried to fulfill my trust. It was his wish that Volume I should not appear until Volume III was finished. Now, with the completion of the third volume of the series, the first three volumes are given to the world reverently and with the conviction that they will be appreciated and understood by his friends and followers.

Lester Ward saw the light; he saw it steadily and saw it whole, and it was his unswerving purpose to open the eyes of others to his vision. This purpose he accomplished; for though few of his readers

are gifted with the clear insight of this great thinker, yet it is vouchsafed, even unto the least of these, now and then, to catch glimpses of his cosmos.

SARAH E. SIMONS.

Oct. 1, 1913.

If in the morning of philosophy,
Ere aught had been recorded, nay perceived,
Thou, with the light now in thee, couldst have looked
On all earth's tenantry, from worm to bird,
Ere man, her last, appeared upon the stage—
Thou wouldst have seen them perfect, and deduced
The perfectness of others yet unseen.
Conceding which,—had Zeus then questioned thee
"Shall I go on a step, improve on this,
Do more for visible creatures than is done?"
Thou wouldst have answered, "Ay, by making each
Grow conscious in himself."

—ROBERT BROWNING. *Cleon.*

FOURTH PERIOD:—Revival of the love of nature of boyhood.

Auf den Bergen ist Freiheit! Der Hauch der Grüfte
Steigt nicht hinauf in die reinen Lüfte;
Die Welt ist vollkommen überall,
Wo der Mensch nicht hinkommt mit seiner Qual.
—SCHILLER.

FIFTH PERIOD:—Botanical activity.

Flower in the crannied wall,
I pluck you out of the crannies,
I hold you here, root and all, in my hand,
Little flower—but if I could understand
What you are, root and all, and all in all,
I would know what God and man is.—TENNYSON.

SIXTH PERIOD:—Philosophical work begun.

Les grandes pensées viennent du cœur.
—VAUVENARGUES.

From this hour I ordained myself loosed of limits and imaginary lines,
Going where I list, my own master total and absolute,
Listening to others, considering well what they say,
Pausing, searching, receiving, contemplating,
Gently, but with undeniable will, divesting myself of the holds that would hold me.—WALT WHITMAN.

'T was in my plan to look on real life,
The life all new to me; my theories
Were firm, so them I left, to look and learn
Mankind, its cares, hopes, fears, its woes and joys;
And as I pondered on their ways, I sought
How best life's end might be attained—an end
Comprising every joy. I deeply mused.
—ROBERT BROWNING.

SEVENTH PERIOD:—The animal ancestry of man. Haeckel's Anthropogenie.

And, striving to be man, the worm
Mounts through all the spires of form.—EMERSON.

Man climbs his own
ancestral tree.—MILNE-EDWARDS.

Die Entwickelungsgeschichte der Organismen zerfällt in zwei nächst verwandte und eng verbundene Zweige: die *Ontogenie* oder die Entwickelungsgeschichte der organischen *Individuen*, und die *Phylogenie* oder die Entwickelungsgeschichte der organischen *Stämme*. Die Ontogenie ist die kurze und schnelle Recapitulation der Phylogenie, bedingt durch die physiologischen Functionen der *Vererbung* (Fortpflanzung) und *Anpassung* (Ernährung). Das organische individuum weiderholt während des raschen und kurzen Laufes seiner individuellen Entwickelung die wichtigsten von denjenigen Formveränderungen, welche seine Voreltern während des langsamen und langen Laufes ihrer paläontologischen Entwickelung nach den Gesetzen der Vererbung und Anpassung durchlaufen haben.—ERNST HAECKEL.

EIGHTH PERIOD:—Passage from the amateur to the professional stage. Incorporation in the scientific world. First great opportunity.

Chaque individu, depuis l'instant de sa naissance, se trouve dans un concours de circonstances qui lui sont tout à fait particulières, qui contribuent, en très-grande partie, à le rendre ce qu'il est aux différentes époques de sa vie, et qui le mettent dans le cas d'exercer ou de ne pas exercer telle des facultés, et telle des dispositions qu'il a apportées en naissant; en sorte qu'on peut dire, en général, que nous n'avons qu'une part bien médiocre à l'état où nous nous trouvons dans le cours de notre existence, et que nous

devons nos goûts, nos penchants, nos habitudes, nos passions, nos facultés, nos connaissances, même aux circonstances infiniment diversifiées, mais particulières, dans lesquelles chacun de nous s'est rencontré.—JEAN LAMARCK.

Ah, fragments of a whole ordained to be,
Points in the life I waited! What are ye
But roundels of a ladder which appeared
Awhile the very platform it was reared
To lift me on? That happiness I find
Proofs of my faith in, even in the blind
Instinct which bade forego you all unless
Ye led me past yourselves. Ay happiness
Awaited me; the way life should be used
Was to acquire, and deeds like you conduced
To teach it by a self-revealment, deemed
Life's very use, so long! Whatever seemed
Progress to that, was pleasure; aught that stayed
My reaching it—no pleasure.—ROBERT BROWNING.

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Glimpses of the Cosmos

October 8, 1875—Ætat. 54.

71. Rocky Mountain Flora

History.—Written at Glenwood, Utah, May 21 to June 9, 1875, and mailed to Mr. Whitelaw Reid, Editor of the *New York Tribune*, on the latter date. I had written to Mr. Reid before starting for the West that I might send him some letters, and received a letter from him saying that the *Tribune* would be likely to use them, but this was not used till I had returned from the field, and the others that I had sent were returned to me unused. This one was republished in the *Daily Tribune* of Nov. 27.

New York Semi-weekly Tribune, Vol. XXXI, No. 3,169, October 8, 1875, p. 3; New York Daily Tribune, Vol. XXXV, No. 10,814, November 27, 1875, p. 10.

GLENWOOD, UTAH, Sept. 15.—A ride across the Western plains and Rocky Mountains is so common an occurrence in these days that no account of it, however graphic or glowing, will be tolerated by the reading public. One

would think, after all that has been said respecting this Western country, that the traveler must start out with something of an accurate conception in his mind of what kind of a region it is. I know not but such is generally the case. I only know that it was not my case. Whether due to my insufficient reading, or to my strong inclination to judge other lands by those I was familiar with, I certainly failed to acquire a reasonably correct notion of the Rocky Mountains and this entire geological formation. I might almost say that the most prominent characteristic of the Rocky Mountain region, as distinguishing it from the Allegheny region, is the absence of timber. As I looked out of my car window while riding through the States of Pennsylvania, Ohio, Indiana, and Illinois, and carefully noted the appearance and disappearance of the different trees, giving character to the landscape; as I saw pass out of view one after another the hemlock, the birch, the beech, and lastly the oak, I little dreamed I had seen the last of these noble trees until I should greet them, as I shall greet my friends, on my return. I gazed at the last straggling trees as they whipped by me at greater and greater intervals, and with a sort of pleasant contempt I said to myself, "Wait till I reach the Rocky Mountains, with their gorgeous scenery of rocks and woods." Alas, my ignorance! Rocks indeed, but woods nowhere. The mountain pass through which the Union Pacific road runs, and which my imagination had pictured with rocky walls and timbered gorges, presents the aspect of a vast plain. Forests there were none; timber, in any proper sense of the term, there was none; trees, except far up in the highest mountain cañons, there were none. The Platte and its tributaries flow sluggishly along through the shifting sands, frequently changing their course and washing out new channels, and always without a tree or a willow or a shrub, without even a taller or greener kind of grass to mark their position on the plain. The approach to the mountains is marked by bluffs, which bound the channels of erosion, and on whose rocky

crags there grow a few dwarf and scrubby evergreens. Far up on the mountain sides are to be found occasional clumps of poplar, called by the settlers "quaking asp," which, with an occasional cottonwood in certain cañons, and sometimes a few box-elders (*Negundo*) along mountain streams, constitute all that can claim the dignity of foliage trees in the Rocky Mountain region. High up amid the almost perpetual snows, but always within mountain cañons and gorges, there grow some large trees of the pine and fir tribe, but the great Sequoia, or giant cedar of the Sierra Nevada, does not, so far as I am aware, occur in the Rocky Mountain region. And having said this much, I have said all that can be said for the so-called timber of this country. The oak, though botanically similar to the most valuable of our Eastern species (the White Oak, *Quercus alba*), is a straggling shrub of dwarf and wretched aspect. One species of maple is reported which I have not seen (*Acer grandidentatum*), which is said to attain a hight of 30 feet. Another species (*A. glabrum*) is only a shrub, while the maple—like box-elder (*Negundo aceroides*) is a small tree in the East, and still further dwarfed here. The two kinds of ash (*Fraxinus anomala* and *Fr. viridis*) are low, never attaining a greater hight than 15 feet. Two birches (*Betula occidentalis* and *B. glandulosa*), the former peculiar to this region, are mere shrubs, while the beech, the elm, the hickory, the walnut, the linden, and all the rest of the valuable timber and ornamental trees of the East, stand unrepresented even in miniature throughout this vast region. The only thing that can be called timber belongs to the pine and fir tribe. The rest of the evergreens are dwarf and scrubby. The hard woods mentioned are so scarce as to produce no effect upon the landscape, and are of no service as lumber. In the latter respect the only foliage tree of any use is the poplar, which is frequently brought down the mountains, and trimmed for fence poles.

Botanical rarities aside, therefore, the trees of the Rocky Mountain region may be reduced to two kinds: Of foliage

trees (*Laubholz, Angiosperms*), poplar or aspen (*Populus tremuloides*), and cottonwood (*Populus balsamifera*, var. *augustifolia*): of evergreen trees (*Nadelholz, Gymnosperms*), three or four species of pine, as many of fir (Abies), and two or three cedars (Juniperus). These—except the last named—all grow at great altitudes, and, with the exception of the first and last, in deep gorges or cañons.

CHARACTER OF THE VEGETATION.

Next to the great contrast that exists between the timber of the Allegheny and that of the Rocky Mountain region comes that which exists between the remaining vegetation. I do not except the geological aspects of the two districts, for in both there are hills and valleys, lakes and rivers, and all the diversified character of the surface which the igneous and aqueous agencies acting alike on both have produced. One is apt to be deceived in a matter of this kind, and attribute too much to the character of the surface and too little to that of the vegetation. It was one of Alexander Humboldt's characteristic remarks, that of the three great kingdoms of nature, the animal, the vegetable, and the mineral, it is the vegetable world that contributes most to mold the character of mankind. Living creatures hide away from human gaze and for a part of the time withdraw their influence. The rocks and the streams are comparatively stationary, and only change as man changes place. But the forest and the meadow, the flowers and the fruits, possess the life of the former without its uncertainty, and the permanence of the latter without its monotony. They are ever present, yet ever changing. If this reflection of the great German be a sound one (and the influence of physical surroundings is being daily more and more clearly recognized as a prime factor in the civilization of every people), it may explain in part the force with which this contrast made itself felt to my mind, and the certain undefined sense of deficiency which I cannot dispel as I look out upon the comparatively

barren hills and plains of the West. For not here as there do we behold the ground clothed with vegetation. Not only are there no forests, no shaded glens, no groves, no leafy canopy, but neither are there any greensward beneath our feet, any carpet of grass, any running vines, any green herbage. The rocks are never covered with moss, rarely with lichens. Three-fourths of the ground is everywhere bare and exposed to the perpetual rays of the sun! "What then," you will ask, "is the character of the vegetation?" I will try to give you an idea of it. In so doing I will confine myself a little more strictly to the mountainous country by excluding the great plains that stretch from the Missouri westward to it, and on which no shrubby vegetation grows, but where the famous "buffalo grass" (*Buchloe dactyloides*) abounds, along with many other kinds of grass and many herbs and weeds, as well as large clumps of cactus. As a general thing, however, it may be stated that this great grassy expanse lacks in a conspicuous manner the close contiguity of greensward and roots, forming genuine turf, which characterizes the prairies of Illinois and Iowa and the meadows of the East. And this tendency of the grass and other herbage to grow in clumps, leaving intervals of bare ground between them, shows itself more and more as we proceed westward, until, when we reach Cheyenne, one finds that not more than half the ground is covered with any kind of vegetation, and further on the characteristic barrenness of the Rocky Mountain region begins to be manifest. A little before reaching the proper divide between the Atlantic and Pacific slopes, and not far from Laramie Station, the characteristic features of the vegetation of this western country begin to appear. In every country there are certain forms of vegetation which predominate to such an extent as to give the leading character to the landscape. Set down in a list, these prevailing forms, which can often be counted on the fingers, bear a very insignificant proportion to the aggregate of vegetable products to be found where they occur, and are outnumbered

by the list of mere curiosities which the scrutiny of collectors reveals, where the popular eye sees nothing. This predominance of a few leading forms, though common to all countries, differs in degree in different countries. In the South American forest, as Humboldt and Agassiz have shown, there are hundreds of trees and shrubs and vines belonging to different genera and orders, all crowding each other and interlacing their branches and foliage so as to render them absolutely impassable, to no one of which can the honor of supremacy or predominance be assigned. In the Allegheny region, both in the timber and in the more humble kinds of vegetation, it is often difficult, out of a dozen or two forms, to decide to which to ascribe this title. In this Rocky Mountain region, however, the opposite extreme occurs. The almost exclusive predominance of a very few plants may be said to constitute the leading characteristic of the vegetation. If the exact proportion of vegetable force exerted by each plant and tree could be calculated and determined, I should not come far amiss if I were to predict that 50 per cent of it all would have to be credited to one single plant—the notorious "sage bush" (*Artemisia tridentata*). This plant ranges from Oregon to Arizona and from the mountains of Colorado to the Sierra Nevada, and is found both at the lowest and the highest elevations, except, perhaps, those of perpetual snow. But its range is less remarkable than its almost universal prevalence and abundance. In fact, with the exception of a few strongly alkaline flats, some overflowed marshes, and in the heart of the pine, fir, and poplar forests of the mountains, it is *everywhere*. It is a low, straggling shrub, growing from one to six feet high, but usually to about a uniform hight of two or three feet. The trunk sometimes attains a diameter of eight inches, though rarely more than three, usually growing crooked, winding, squat, and scrubby. The bark is brown and ragged, and the wood dark colored, pithy and brash. It has branches from rather low down, forming a scraggy and uneven bushy top. The leaves, which

are very numerous, are small, have the shape of a wedge with the small end next to the stem, and with three blunt teeth at the broad apex. They are covered, as are also the young branchlets, with a fine whitish down (tomentose-canescent), precisely as in the garden sage, and, like that plant, emit a strong but not unpleasant odor, though quite distinct from that of sage, and between it, as I should say, and that of tansy. This odor is constantly perceptible when passing through the sage brush. Unlike most brush of the East, the sage brush opposes travel very little. The bushes stand from two to eight feet apart on the ground, and if the sun were vertical would shade much less than half of it. Nor is the rest of the ground shaded by other vegetation. Whatever else grows with it (and it is very little) is small and keeps close to the roots of the sage. But the sage brush seems to completely monopolize, not only the soil but the atmospheric conditions as well. Its roots are small and do not spread or penetrate deeply, showing that it is at best a sort of aërophyte, and only requires a foothold on mother earth. Its relationship with the true sage ends with its conescence, its odor and its name, and none of these have any botanical value. The first is shared by thousands of plants, especially in this country. The second is of doubtful resemblance, and the third it is not responsible for. Its Latin name is a far better guide to its pedigree. It is an Artemisia, belongs to the wormwoods, and has for its cousins tansy, chamomile, and milfoil. In a word, it is a composite, and not, as the true sage is, a labiate plant. I should not pass by this famous and universal form of plant growth without mentioning its congeners, some dozen of which are found here, often associated with it, always smaller and less obtrusive, but always bearing not only the whitened appearance and aromatic odor, but also the name of sage.

THE GREASEWOOD PLANT.

Next after the sage brush, in point of physiognomic

importance, comes the less agreeably but more appropriately so-called "greasewood." I should say at the outset that this term is indiscriminately applied to several different plants, though of somewhat similar aspect, all agreeing in belonging to the "goosefoot" or "pigweed" family (*Chenopodiaceæ*). Not that the inhabitants of the mountains are not keen observers enough to have seen the difference, but from their general resemblance, particularly from the greasy (furfuraceous) appearance of their foliage, they have dubbed them all with the general name of "greasewoods," without, so far as I know, having invented more specific names for the different kinds. They all have a decided family resemblance, though they have been placed under several distinct genera. But as in the "sages" there is one leading form that eclipses in its ubiquity and abundance all others, so among the "greasewoods" there is one shrub that is undisputably the "greasewood," though it cannot compare, either absolutely or relatively, to the rest of that name, either in universality or interest, with the prevailing form among the sages. In working up the botanical collections made by Col. J. C. Fremont, Dr. Torrey first christened this plant *Fremontia vermicularis*, and it is to be regretted that this name should have been subsequently made to yield to that assigned to it by Nees von Esenbeck of *Sarcobatus vermiculatus*, although no one can find fault, as the description will show, with the appropriateness of the German's etymology. It is a homely shrub, growing from two to six feet high, branching irregularly, and bearing at the extremities of its branches very many spiny projections, which are not true thorns, but seem to serve the same purpose to the entire satisfaction of all men and animals. These spines are simply the dry and dead remains of the fruiting branches of preceding years, from which the flowers and seeds have fallen off, and the bark at the extreme ends where it was tender has disappeared, leaving only the more central woody parts, and this being smaller toward the end and always central, the natural

result of the sloughing off of the deciduous parts is to leave a conical or spinous projection. These thorns are rough and uneven on their outer surface, most generally compound and never very sharp. This description will apply to nearly all the spinescent shrubs of this country.

Sarcobatus has numerous long and narrow leaves, which are thick and sparingly covered with the characteristic mealy look, which is not very inappropriately denominated "greasy." It bears male and female flowers, which do not in the least resemble each other, in different places on the same plant (monœcious), or sometimes on different plants (dicœcious). The male flowers are crowded together in numerous worm-shaped, catkin-like spikes at the ends of the branches, conspicuously topping out the bushes. The female flowers are wholly inconspicuous, being located in the axils of the leaves. Both are green, except an occasional purple tinge to the catkins where strongly exposed to the sun. But as the female (fertile) flowers develop into the fruit they present a large round wing, which renders them very obvious. The chief peculiarity of this shrub is its strong predilection for alkaline soils. In fact I believe it grows in no other, and by its presence, without resorting to analytical tests, the alkaline areas can be determined. But it does not like too much alkali. There are large tracts here which are incrusted with a white layer of alkaline salts, which the mountaineers call "saleratus beds," and in which very little vegetation can live. Still in the densest of these there is one strange, leafless, jointed shrub almost universally found. Its Latin name is *Halostachys occidentalis*, and I do not know that it has any other. Returning to Sarcobatus, I need only add that it stands next to the "sage brush" in its usurpation of the soil, constituting almost the only vegetation in some valleys over many square miles. Its thorny character is not very objectionable where only cattle or horses have to pass through it, but it is a serious detriment to sheep-raising, being of the right hight to lay hold of the wool and pull it out in locks. I passed through

a large patch of it in the Sam Pitch Valley, where there is a large flock of sheep, and not only were the bushes full of wool, but the sheep had their necks and forequarters in very many cases absolutely bare

As already stated, there are several other kinds of "greasewood," most of which exhibit the peculiar bran-like appearance of the leaves in much more marked degree than Sarcobatus, and at least one of which (*Obione confertifolia*), if the number of plants only be taken into the account, is quite as prevalent. This species is, however, much smaller, rarely over a foot and a half in hight, has broader and thinner leaves, and much sharper and more slender spines. It forms a little round clump-like bush, and prevails extensively, not only in the valleys, often in company with Sarcobatus, but also on the "benches" and foot-hills, along with the "sage brush." From the sharpness of its spines it is the most troublesome (at least to the collector) of all the greasewoods. It is always dicœcious, and the female plants, with their long spikes of winged fruiting bracts, looking like a string of buttons, and persisting through the winter as dry, round, corky scales, form a conspicuous object. *Obione canescens* is a tall shrub without spines, but with very "greasy" leaves. It is very common, but does not hold any monopoly over other things. *Grayia polygaloides* is the best looking (or rather the least ugly) of them all, with its winged fruit tinged with purple. *Eurotia lanata* and *Kochia prostrata* are low, and white-mealy, and have a tendency to monopolize, that is, to exclude everything else. They both prefer alkaline soils. Without attempting to enumerate all the species, I must conclude this description of the great family of "greasewoods," which term may be regarded as equivalent to the more scientific term, *Chenopods*, although a few of them, as *Eurotia lanata*, have been dubbed by the inhabitants with the name of "sage." I will simply add that the leaves of nearly every variety of the plants of this family are eaten by stock, and being tardily deciduous, they become in some

cases a main dependence during the prevalence of deep snows.

RABBIT BRUSH.

Next to the "sage brush" and the "greasewoods" in physiognomic importance, and the only remaining form that shares their universality and their spirit of monopoly, must be mentioned the "rabbit brush." There is only one plant that properly claims this title, although there are several smaller plants of near kinship to which I have heard it qualifiedly applied. The botanical name of this plant is *Linosyris graveolens*. It sometimes attains the hight of four feet and is very abundant, constituting nearly the entire herbage in some localities over many acres of ground. Its form in good specimens is rather symmetrical and graceful, contrasting strongly with both the other dominant forms described, being broad and bushy at the top and narrowing down regularly to the base. The round, slender, willow-like branches, and often the very narrow linear leaves, are covered with a white canescence, which characteristic, combined with its broom-like growth, have earned for it in some places the name of "broom-sage," though I have never heard this name applied to it. Neither have I been able to detect sufficient odor from it to justify the specific name, or entitle it to a rank among the "sages" of the West. It flowers late in the Summer, bearing numerous showy corymbs of yellow heads, and belongs, like the Artemisias, to the great composite order. There is probably a good reason for calling it "rabbit brush," and no doubt the hares of this country subsist to a considerable extent on its bark; but, as far as my observation goes, these animals are more frequently seen among the "sage brush." Like the Sarcobatus, this shrub is definitely restricted in its choice of soil, and seems to be confined to a loose sandy soil, being principally found in alluvial bottom lands. There are several other species of *Linosyris* common in the valleys,

all closely resembling the leading form, but much smaller; which are also sometimes called "low rabbit brush." Besides these there are a good many species of the nearly allied genus Aplopappus having more showy flowers with rays, and these are all popularly confounded together.

I have now dwelt sufficiently at length no doubt upon these three great leading forms of vegetation, and will only add in justification of so minute a description that if the reader could, without visiting the country, obtain a clear and just conception of the effect of these three plants upon the landscape, of their vast preponderance over everything else, of their universality wherever one looks, and of how they usurp and monopolize all the vegetal energies of the soil and atmosphere, excluding other forms of plant life in a manner wholly different from anything that exists in the East, he would scarcely need to be told what else grows here or even to visit the country, at least so far as regards the influence which vegetation exerts over the landscape scenery. Of course there would remain plenty to repay him for such a visit, in rock, and stream, and mountain. But he might be sure at all times and under all circumstances to behold the "everlasting sage brush," the homely "greasewood," or the more stately "rabbit brush." The only possible exceptions would be when he should glance at the high mountain cañons looking dark with fir, or their elevated slopes green with the trembling aspen.

72. The Oaks of the District

History.—This was the title of the paper read by me before the Potomac Side Naturalists' Club on Oct. 18, 1875. A fuller account is given under the next title. I furnished a memorandum of the paper to a representative of the press, and the following abstract appeared in the Washington *Chronicle* of Oct. 26. The printers made terrible work with the botanical names. For the initial *Q* of the genus name (*Quercus*) they put the Arabic figure 2. They also misinterpreted many letters and spelled names wrong. These typographical errors are here corrected.

The Washington Chronicle, Vol. XIII, No. 143, October 26, 1875, p. 8.

MR. L. F. WARD read an interesting paper, illustrated by specimens, upon "The Oaks of the District." Of the sixteen species enumerated in Gray's Manual as indigenous to the United States east of the Mississippi, we have in the District eleven, viz., *Quercus alba*, white oak; *Q. obtusiloba*, post oak; *Q. bicolor*, swamp white oak; *Q. Prinus*, chestnut oak; *Q. Phellos*, willow oak; *Q. imbricaria*, laurel or shingle oak; *Q. nigra*, black-jack oak;

Q. falcata, Spanish oak; *Q. coccinea*, scarlet oak; *Q. rubra*, red oak; *Q. palustris*, pin oak.

Besides several varieties of these species, there are also several interesting hybrids, as between *alba* and *Prinus*, *Prinus* and *bicolor*, *nigra* and *tinctoria*, *falcata* and *palustris*, *falcata* and *imbricaria*, this latter hybridization producing what has been called *Q. heterophylla*, and perhaps *Q. Leana*, new specimens of which have been lately discovered in the District.

January 5, 1876—Ætat. 54.

73. Oaks of the Potomac Side

History.—The Potomac Side Naturalists' Club had divided up the botanical work among the members, and the investigation of the trees fell to me. I had made a careful study of the oaks, and presented my results to the Club on Oct. 18, 1875, bringing numerous specimens for exhibition, and my field notes. In fact, I had written a short paper on the subject on Oct. 14–18. When Mr. Charles R. Dodge, Editor of *Field and Forest*, asked me for it for that journal, I revised and expanded it, and gave it to him on the 22d in its present form. It did not appear till Jan. 5, 1876.

Field and Forest, Washington, D. C., Vol. I, Nos. 5 & 6, October and November, 1875, pp. 39-42.

THE oak has been justly regarded in all ages and countries as the emblem of strength and durability. Whatever may be the special advantages possessed over it by any other tree, there is none which can be called its peer when all its good qualities are collectively considered.

Perhaps there is no spot on the continent which has a better claim to style itself the home of the oak than the

valley of the Potomac within a radius of ten miles from the nation's capital. For although the noble Live Oak fails to reach us from the south, and the grand | Mossy-
40 cup Oak from the north; still it may be truly said that these are the only valuable species not found in a native state within the limits named. Besides being the characteristic tree of this region as respects number and abundance, the oak is here represented by an unusual number of species and varieties.

From a somewhat thorough study of the genus in the vicinity of Washington, I find that of the sixteen distinct species enumerated in the fifth edition of Gray's Manual, as indigenous to the Northern United States east of the Mississippi, eleven belong to our district, as follows: *Quercus alba*, *Q. obtusiloba*, *Q. bicolor*, *Q. Prinus*, *Q. Phellos*, *Q. imbricaria*, *Q. nigra*, *Q. falcata*, *Q. coccinea*, *Q. rubra*, and *Q. palustris*.

Among the settled varieties of these we also find distinct examples of *Q. Prinus*, var. *monticola*, and var. *accuminata*, and of *Q. coccinea*, var. *tinctoria*.

In addition to these occur several anomalous forms, presumed to be hybrids, which afford an especial interest. In no less than six of these, after a careful comparison of the leaves and fruit and a close study of their respective localities and of the species growing in the immediate vicinity of each, the original species of whose joint parentage they are the probable offspring can be traced with a considerable degree of certainty.

A peculiar form of *Q. alba*, having leaves with short lobes and shallow sinuses directed much forward, as well as the veining, and thus simulating those of *Q. Prinus*, renders it quite probable that these species have intercrossed.

There are some forms of *Q. bicolor* whose unusually long, narrow and elliptical leaves hint strongly at an affiliation with *Q. Prinus*, var. *accuminata*, while, on the other hand, certain trees belonging unquestionably to the last named variety, not only exhibit the whitened-downy under surface

of leaf characteristic of *Q. bicolor*, but also show a tendency to reduce the number of primary veins to from 8 to 10, thus affording additional proof of the ability of these forms to intercross.

Passing into the biennial fruited division, we observe this process of hybridization still more distinctly manifest.

Certain trees having some of their leaves almost entire, raise a strong suspicion that *Q. imbricaria* has exerted an influence more or less | marked upon *Q. nigra*. Its union with *Q. coccinea*, var. *tinctoria*, rests on a much surer basis. Two trees which I have recently discovered in a wood near the north corner of the District of Columbia, growing in a wild state, have proved unusually interesting. That these should be called *Q. Leana* and not *Q. heterophylla*, I maintain for the following reasons: Their resemblance to *Q. heterophylla*, as it exists in the herbarium of the Department of Agriculture, is not sufficiently close to warrant this name, the leaves being broader and less lobed. They *do* agree substantially with the specimens of *Q. Leana* in that herbarium. They also agree remarkably well with the tree which Mr. W. R. Smith, Superintendent of the U. S. Botanical Garden, has raised in his grounds from an acorn of *Q. imbricaria*. Finally, on considering the locality in which these trees were found, it seems impossible to believe that *Q. Phellos* can have entered into the combination. In the entire wood where they are situated not an individual of that species exists. It is wholly wanting throughout the region of Rock Creek on which the grove is located. On the contrary, the prevailing oak there is *Q. imbricaria*, although both varieties of *Q. coccinea* are also frequent. It cannot therefore be justly claimed that this new discovery constitutes a revival of the famous Bartram's Oak, since this was decided on the highest authority to be either "a form of *Q. Phellos*" or a union of that species with *Q. coccinea*, var. *tinctoria*. It is, however, none the less a botanical curiosity.

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Next in point of interest may be mentioned the supposed

union of *Q. nigra* with *Q. coccinea*, var. *tinctoria*. This tree I found in a grove of second growth timber lying east of the city. Its leaves most resembled those of the latter species but exhibited the rusty-pubescent under surface characteristic of the former with considerable prominence. The acorns, however, which were very abundant, were in all respects those of *Q. nigra*. Its habit was also that of this species, of which several trees stood in immediate proximity to it.

Lastly, there is constantly manifested a tendency on the part of *Q. falcata* and *Q. palustris* to shade off into each other. This happens by a mutual convergence of the two species, both as respects leaves and acorns, so that while an exact medium might be difficult to find, the suspicion is none the less strong that each is capable of impressing its stamp upon the other in more or less marked degrees.

The following tabular exhibit of the oaks of the Potomac side, so | far as I am acquainted with them, specimens of each of which I have furnished to the herbarium of the Potomac Side Naturalists' Club, may serve to make the subject more clear than has been done by the foregoing enumeration.

42

NORMAL FORMS.

Quercus alba.	Quercus imbricaria.
" obtusiloba.	" nigra.
" bicolor.	" falcata.
" Prinus.	" coccinea.
" Prinus, var. monticola.	" coccinea, var. tinctoria.
" Prinus, var. accuminata.	" rubra.
" Phellos.	" palustris.

HYBRID FORMS.

Quercus alba-Prinus.	Quercus imbricaria-nigra.
" bicolor-castanea.	" imbricaria-tinctoria.
" falcata-palustris.	" nigra-tinctoria.

March (?), 1876—Ætat. 34.

74. Winter-blooming Jessamine

History.—Written Jan. 8, 1876. The specimen referred to grew against my own house.

Field and Forest, Washington, D. C., Vol. I, No. 7, December, 1875, p. 56.

THIS season has proved especially favorable for the beautiful winter-blooming Jessamine which adorns several gardens of this city. Notwithstanding the "cold snap" that occurred early in December, the buds have steadily developed and are now (January 15th) in full bloom. A bush, belonging to one of the members of the Naturalists' Club, which has spread extensively over the wall at the southeastern corner of his house, and climbed to the height of ten feet, has its multitude of gracefully drooping branches literally covered with rich yellow blossoms, which, in the absence of foliage and in contrast with the bright green branches, present a very brilliant and unique appearance, the interest of which is heightened by its occurrence in the dead of winter.

It may be of interest to some who have not given themselves the trouble to investigate this highly ornamental exotic, to be informed that it is of Chinese origin and was first introduced into England by Robert Fortune in 1844, where it was cultivated with success, and whence it has

found its way to America. It was named *Jasminum*[1] *nudiflorum* by Dr. Lindley, and is briefly described in Loudon's *Encyclopædia of Plants;* but, strange to say, has not been enumerated in any of our standard text-books, and is not even mentioned in the *Prodromus* of De Candolle.

[1] Here erroneously spelled *Jasminium*, probably a typographical error, as I knew the proper spelling of the genus name.

April, 1876—Ætat. 34.

75. Eccentricity of the Pith of Rhus Toxicodendron

History.—I commenced my investigations of this phenomenon on Jan. 16, 1876. I scoured the country for specimens and made many sections. These I exhibited to the Potomac Side Naturalists' Club on the 24th, and read a preliminary paper on the subject. I continued to find new facts and to remodel my paper to include them, and on Feb. 7th, I read the final draft and showed my specimens to the Club. Then I sent the paper to the *American Naturalist* with much trepidation, as it was practically my first contribution to science, and I was unknown outside of Washington.

The American Naturalist, Salem, Mass., Vol. X, No. 4, April, 1876, pp. 232–235.

MY attention was drawn to this subject by the January NATURALIST. As is well known, this handsome but much-dreaded climber, so common in all our wood lands, has the habit of adhering tightly to the trees which it ascends by a multitude of aerial rootlets, which often cover its stem and give it the appearance of being embedded in a cushion of moss.

The results of my investigations on the stems of this plant are somewhat curious. The fact itself that the pith, wherever the vine is found adhering closely to living trees, lies very near the outer side, leaving a largely disproportionate amount of the woody tissue on the side next the tree, is, so far as I have observed, universal. The following observations will give an idea of this disproportion:—

In a vine 5½ lines in diameter the distance from the centre of the pith to the inner margin was 4¾″, and to the outer only ¾″. This proportion held uniformly for various heights from the ground. The measurements included the bark, which, as well as the annual rings, partook of the general tendency, and was much thinner on the outer side.

A larger vine, upwards of an inch in diameter at the base, had climbed | a cedar-tree (*Juniperus Vir-*
233 *giniana* L.) to the top, and, no longer finding anything to adhere to, sent out free fruiting branches nearly half an inch thick. Of this I took several measurements. Two and a half feet from the ground, where the diameter was 10½″, the distance from centre of pith to inner edge was 8½″, and to outer 2″. A foot lower the proportion had decreased to that of 9″ to 2½″ in a diameter of 11½″. Ten inches lower still it had further decreased, so that the pith was still 9″ from the inner, but 4½″ from the outer margin. The ratios between the two distances in descending the stem were therefore, respectively, 4¼, 3⅗, and 2. Above the first-mentioned point the position of the pith remained nearly unchanged.

A very large vine, nearly four inches in diameter, gave less marked results. Sections not being exactly circular, linear measurements could not be relied upon, but a line drawn through the heart, parallel to a tangent at the point of contact with the tree to which it adhered, showed a decided preponderance of wood in the inner segment. The adhesion in this case, however, as is probably the case with all large vines, was slight, the rootlets appearing to lose their vitality with age. The vine divided at the height

of eight feet, and the branches, which adhered more closely, showed a greater eccentricity.

Numerous observations were made on other vines thus normally situated, with substantially the same results. One case in particular, however, exhibited the extreme of the phenomenon, the cellular dot approaching to within a fourth of a line of the membranous bark. Indeed, so anxious did it seem to remove itself to the greatest possible distance from the tree that for the greater part of the way there was a manifest ridge running along the back of the stem, in which the pith was situated.

These facts, however, uniform and singular as they are, could not in themselves be regarded as sufficient to demonstrate the absorption of sap from the supporting trees by the rootlets. To satisfy such an assumption certain tests must be applied. The first that suggested itself to me was that of making similar observations at points where, for any reason, the vines had swung loose from their support, so that no connection should exist by means of the rootlets. Many such cases were found and examined. The larger vine first referred to, which at a distance of two feet and a half from the ground, where the attachment was firm, measured $8\frac{1}{2}''$ to the inner and $2''$ to the outer margin, giving a ratio of $4\frac{1}{4}$ between the measurements, had the pith located $5\frac{1}{4}''$ from the inner and $3\frac{3}{4}''$ from the outer margin, a ratio of $1\frac{2}{5}$, at a point some six feet higher, where it had become detached. In this example it was evident that there had formerly existed some degree of attachment. At other points higher up, where there were less signs of its having ever adhered, the pith was found to be nearly central, while on the projecting branches of the same vine, bearing the berries and showing no tendency to cling, there was no appreciable eccentricity. Another small vine, which ad|hered for four feet and then swung away 234
for two feet, reattaching above, had the pith decidedly more central at the detached part than at points either above or below. The extreme case to which I referred, where the pith

actually ran through a tube slightly raised above the outer surface, showed a transition from this state of extreme eccentricity to one of centrality in the space of one foot where the vine suddenly abandoned its support.

The function assigned to the rootlets by the hypothesis is one of parasitism. They are assumed to penetrate the bark as far as the cambium layer, and remove the sap of the tree, appropriating it directly to the vine. This nutrition, being ready-made, would naturally be deposited at the nearest point of contact, and thus account for the great preponderance of woody tissue found on the side next the tree. It would therefore follow that this eccentricity of pith should not exist where the support is not a living tree. To test this question, I sought out a small vine of the same species which climbed and closely adhered with a profusion of rootlets to a perfectly dry stone wall ten feet in height. This I examined most carefully, and accurately measured at various points, finding the position of the pith uniform at all distances from the ground. The following measurement will therefore answer for all: Three feet from the base, where the diameter was $4\frac{3}{4}''$, the pith was $2\frac{3}{4}''$ from the inner and $2''$ from the outer edge, or within three fourths of a line of the centre.

One other class of instances seemed to bear directly on this point, and to these I gave special attention. I refer to vines found climbing fences and posts under varying circumstances. The results obtained from these were perhaps the most surprising of all. One $5\frac{1}{4}''$ in diameter tightly hugged a decayed fence post, insinuating its rootlets deeply into the soft surface. Of this the pith was $4''$ from the inner and $1\frac{1}{4}''$ from the outer margin, giving the astonishingly large ratio of $3\frac{1}{5}$. A section of a larger stem ($11''$) similarly situated, and whose rootlets tore away considerable of the decayed wood in detaching it, showed the centre of the pith to be $7''$ from the inner and $4''$ from the outer margin. Considering the size of this vine the eccentricity was large.

Where the wood to which the vines adhered was not decayed or soft, a marked diminution in the eccentricity was perceptible. In one instance where the rootlets clung very tightly to a dry surface, which had moreover been charred and where penetration was impossible, the measurements were respectively $3\frac{1}{2}''$ and $2\frac{1}{2}''$, or an eccentricity of half a line in a diameter of half an inch.

So far as my observations, which were numerous, extended, it seemed to be the law that, *cæteris paribus*, the softer the wood to which the rootlets adhered, the greater the eccentricity of the pith.

Without going further into details, therefore, the whole subject may be thus briefly summed up:—

(1.) The pith of the poison ivy, wherever the vine 235
is of moderate size, and is found adhering closely either to the bark of a living tree or to any soft, decaying substance, is located from three to ten times nearer the outer than the inner side of the stem, and sometimes still more eccentrically; the annual layers of wood as well as the bark becoming correspondingly thickened on the side next the support.

(2.) This eccentricity diminishes and frequently disappears altogether at points where there is no attachment by the rootlets.

(3.) It is greatly reduced in vines which cling to hard substances which the rootlets are unable to penetrate, as a stone wall or a dry post.

That all these facts are in harmony with the theory of the absorption of nourishment from the support, in so far as any form of parasitism is implied, cannot of course be maintained. The last class of observations described may be regarded as directly negativing such an assumption. Besides, I have seen nothing to render it probable that the rootlets ever pierce the outer bark. But, on the other hand, these facts do all unite in pointing to a physical connection of some kind between the penetration of the rootlets and the eccentricity of the pith. The notion thus

far entertained, and which has found its way into our standard text-books, that these rootlets are "not for absorbing nourishment, but for climbing,"[1] may in future require some modification. Yet, admitting this physical connection, there remain puzzling physiological questions. If these rootlets perform the function of true roots, and find congenial soil in the corky layer of bark, in the soft mass of decomposed wood, and even to some extent in the minute cryptogamic vegetation that always exists among them even when clinging to walls of brick or stone, how does this explain the singular behavior of the pith and the strange eccentricity of the annual rings?

[1] Gray's Lessons, p. 34.

76. Damiana.—Description of Turnera aphrodisiaca Ward

History.—On January 13, 1876, while I was working up my Utah collection at the Department of Agriculture, a certain Dr. Helmick called with several plants from Old California to be determined. Dr. Vasey promptly determined all but one of them, but that one was very puzzling. It was, moreover, the important one, being claimed to have remarkable medical properties, and to be an aphrodisiac. The name *Damiana* had been given to it and to the drug prepared from it, and Dr. Helmick was very anxious to know what it was, and to have a botanical report on it. The specimens were very poor, all dried up and mostly devoid of leaves, flowers, or roots, though a few dried leaves and buds adhered to the naked stems. He had sent it to Dr. Rothrock, who had been unable to determine the genus of plants to which it belonged, but had proposed that the name *Damiana* be given to the species.

At first I had no intention of doing anything about it, and left its determination to Dr. Vasey,

Head of the Division, and leading botanist of the country. But he finally gave it up, and on the 21st asked me if I wanted to try my hand at it. It evidently did not belong to any of our Northern genera, and must be sought in general works covering the whole world. The only such work at that time was Bentham and Hooker's *Genera Plantarum*, and Dr. Vasey could not read Latin well enough to pursue it there. "I made a thorough dissection of two flowers that I found and a fresh capsule, writing out a complete description. Then I took Bentham & Hooker and pursued it with unerring pertinacity, till at 1-30 I had traced it to the genus *Turnera*." The above is copied from my note-book. The species did not seem to be described in de Candolle's *Prodromus*. The matter rested there for six weeks, when Dr. Rothrock, having learned that I had determined the genus, proposed to call the plant *Turnera Damiana*. This Dr. Helmick saw to be unjust to me, and urged me to name it. I therefore proposed the name *Turnera aphrodisiaca*, and he hastened to publish my description in the *Virginia Medical Monthly*. The following is the part of his article introductory to my description:

47 **Damiana—Its Botany.**—As the first article on damiana, published in this country, appeared in the *Monthly*, May, 1875, and as favorable reports concerning its therapeutical action are accumulating rapidly, we have compiled the following botanical description from a mass of correspondence in our possession:

Dr. D. G. Brinton, editorially (*Med. & Surg. Reporter*,

March 4), calls attention to an article in the same number of his journal by Dr. J. T. Rothrock, of Wilkesbarre, Pa., which, it is claimed, "dispels wholly the mystery which charlatanism has endeavored to throw around this drug." Dr. R. describes a plant, received from Monterey under the name of damiana, which is well known to botanists as belonging to the family of "compositæ," genus "Bigelovia," of Gray, and described by Dr. Asa Gray as "Bigelovia veneta."

Mr. Wellcome has described (*Amer. Jour. Pharm.*, 1875, p. 518) three distinct plants—each of which goes by the name of damiana in the New York market. Two of these plants also are very different from the specimens that come from Dr. Helmick, of Washington, and which alone seems entitled to therapeutic respect. It is this latter specimen to which Dr. Caldwell's paper (*Va. Med. Monthly*, May, 1875,) relates. It is but due to Dr. Helmick to state that he has supplied a number of botanists with specimens, and has had the fairness to court investigation. 48

Since the appearance of Dr. Rothrock's article, it is also due to this author, as also to Dr. Asa Gray, to say for them that they have examined specimens furnished by Dr. Helmick himself, and they unhesitatingly affirm that it is a different botanical plant from that described in the *Reporter*.

During January, 1876, Mr. Lester F. Ward determined the plant to be a species of *Turnera;* and not finding a specimen in the National Herbarium, nor finding any satisfactory description of the species in De Candolle's *Prodromus*, or any accessible works, he proposed for it (without meaning thereby to endorse its alleged medicinal virtues, which must be decided by clinical experience) the provisional name *Turnera aphrodisiaca*, in case it should prove not to have already received a name. Dr. Gray "willingly leaves it in the hands of Messrs. Vasey and Ward," and Dr. Rothrock likewise yields his views "*concerning its*

botanical history." We are advised that Professors Vasey and Ward, recognizing a new plant in the so-called "Damiana"—or at least one not described in any of the authorities—have recently fixed the botanical name of Damiana as *Turnera aphrodisiaca.*

Virginia Medical Monthly, Richmond, Virginia, Vol. III, No. 1, Whole number 25, April, 1876, pp. 48–49.

THE following is the description given of the plant last January by Dr. Ward, and which description is now adopted:

"Calyx tubular, funnel form, the lobes shorter than the tube. Styles 3, distinct. Stigmas flabellate. Stems woody, the branches reddish, densely canescent or lanulose, as well as the petioles and lower portion of the midrib. Leaves obovate to oblanceolate, 6 to 9 lines long, 2 to 3 lines wide, on short petioles, strongly crenate-dentate, the teeth with revolute margins, prominently veined beneath, nearly glabrous above, glandular below, bearing fascicles of smaller leaves in their axils, together with the flowers. Flowers short-pedicelled or nearly sessile, axillary or petiolary, *i. e.*, developed either from the center of axillary fascicles of minute leaves, or from between these and the base of the petioles, or, in some cases, from the petiole itself above its base; bibracteolate, the bracts ovate, long acumi-
49 nate, ciliate. Anthers somewhat sagittate, introrse, the cells thin, ovaries dehiscent from the apex to near the base. Seeds large, long kidney-shaped or curved, grooved lengthwise and pitted; only a few maturing, the rest abortive and persistent.

Among other particulars in which *Turnera aphrodisiaca* differs from *T. carpinifolia*, with which it is most apt to be confounded, is the fact that the latter is a native of damp river bottoms in South America, while the former plant is found only on dry, rocky places in Western Mexico. In addition, a comparison of the above description of *T.*

aphrodisiaca with that of *T. carpinifolia*, as found in De Candolle's *Prodromus*, shows a want of harmony in some of the most important characters. The leaves of that species are there described as oblong lanceolate, doubly serrate, puberulent and bi-glandular, in all of which positive characters (not to speak of certain negative ones too patent to be overlooked in a work of its kind) there is a want of correspondence."

77. A New Fir of the Rocky Mountains

History.—Written June 29–30, 1876. Dr. Vasey accepted this name in his report on the Centennial collection,[1] and credits the description to me. It is No. 381, and occurs on p. 420. I probably furnished it to him exactly as it stands. It is as follows:

Abies sub-alpina, Eng.—Sub-alpine Balsam.—Rocky Mountains. This is one of the tallest and handsomest firs of the Rocky Mountains, often attaining a height of 80 or 90 feet; perfectly straight, and without limbs for a great distance. The wood is white, soft, and of little value for lumber. It is known among the lumbermen of the Wasatch Mountains as White Balsam, or Pumpkin-tree. Its nearest affinity is to *A. balsamea* of the Eastern States. It reaches to great altitudes, being sometimes found near the timber-line. It has often been collected, and generally referred

[1] A Catalogue of the Forest Trees of the United States which usually attain a height of sixteen feet or more, with notes and brief descriptions of the more important species, illustrating the Collection of Forest-tree Sections on exhibition at the Department of Agriculture at the International Exhibition, 1876. Prepared by Geo. Vasey, M.D. International Exhibition, 1876, Vol. II. Department of Agriculture, pp. 381–426.

to *A. grandis*, the incorrectness of which has been but lately pointed out by Dr. Engelmann, who has proposed for it the name given above.—(Ward).

I again described it, and almost in the same words, in my report to Major Powell on the timber-trees of Utah (see *infra*, No. 101). In 1897 Sudworth[1] referred it to *Abies lasiocarpa*, in which he was followed by Sargent, Heller, and others, and it was long supposed that the form I collected was only a local variant of a much more widely distributed tree. But quite recently (1912) doubts have begun to arise, and Mr. Coville is instituting a thorough investigation of the whole subject, and has asked me for more specific information as recorded in my note-book, which of course I have furnished him.

The American Naturalist, Boston, Vol. X, No. 9, September, 1876, pp. 553–555.

WHILE collecting in the Wasatch Mountains, in Eastern Utah, last summer, for Major Powell's Survey of the Colorado, I obtained five species of fir, two of which possess a special interest, growing out of the confusion which has heretofore existed respecting the group to which they belong, and the fact that one of them bids fair to be established as a new species. The other turns out to be *Abies concolor* Eng., and not *A. grandis* Lindl., as was supposed, and under which name this tree has been several times reported. | The leaves of
554 my specimens are not glaucous above, but underneath only or not at all, this character not being a

[1] Nomenclature of the Arborescent Flora of the United States, by George B. Sudworth, Bulletin No. 14, U. S. Department of Agriculture, Division of Forestry. Washington, 1897, p. 53.

constant one. This tree is there known to the Mormon lumbermen as "black balsam" and makes an excellent quality of lumber. It is rarely found above 8500 feet altitude, or below 7000 feet.

But there was another tree there, very much resembling this in its botanical characters, though differing widely in other respects, which I well knew to be a different thing, and as it answered to no description I could find, I became deeply interested in it. In altitude it commences just where the other leaves off, and continues on up nearly to the timber line, or over 11,000 feet altitude. I found it both in the basin of the Sevier River, above Gunnison, and also far to the eastward across the divide on the Colorado side, high up on the slopes of Aquarius Plateau and Thousand Lake Mountain. This tree is distinguished by the lumbermen of that region as "white balsam." It is also known as "pumpkin pine," the wood being rather spongy and poor for lumber. But otherwise it is a much finer tree than *A. concolor*, being very tall and straight, with few limbs from its lower trunk. Of both species I brought back specimens, not only of the leaves, cones, etc., but also sections of the trunk for exhibition at the Centennial, where they may now be seen in Dr. Vasey's excellent collection sent from the Department of Agriculture. I also sent specimens to Dr. Engelmann for identification, from whose report, as follows, it appears that both the species above mentioned have been heretofore confounded under the name of *A. grandis* Lindl., inapplicable to either.

"*Abies subalpina* is the provisional name Dr. Engelmann gives to that fir which occupies the highest wooded regions up to the limits of vegetation in the Rocky Mountains, from Colorado northward and westward to Oregon. In lower altitudes it is replaced in Colorado and Utah by *A. concolor*, and in Oregon by *A. grandis*. All the specimens sent from Colorado by Parry, Hall, and others belong here; but in Oregon collections it is mixed with *A. grandis*, and in both regions has been designated by this latter name.

Its nearest affinity is not to any western *Abies*, but to the eastern *A. balsamea*, of which it may prove a geographical variety. Its leaves are shorter than those of *A. grandis*, those of the lower sterile branches are slightly emarginate, on the upper side grooved and without stomata. The leaves of vigorous shoots and of cone-bearing branchlets are acute, above convex and provided with stomata. The cones are purplish brown, the scales scarcely wider than long; the bracts are variable in this as in most other species, and not of much diagnostic value. Mr. A. Murray has, in an Oregon specimen collected by Dr. Lyall, noticed this difference of leaves of sterile and fertile branches, and therefore named it *A. bifolia;* this, however, is a misnomer, indicating something very different from what he intended, and cannot stand.

"In a paper shortly to be published in the Transactions of the St. Louis | Academy of Science, Dr. Engelmann has gone more extensively into the different questions relating to the North American species of Abies." 555

Until this very needful revision appears, the following characters, drawn from my own specimens, may serve to designate more particularly our welcome newcomer from the mountains.

Abies subalpina Eng., n. sp. Tall and slim, 80 to 100 feet high, often 50 feet without branches; bark smooth, white, and covered with vesicles to near the base; leaves 6 to 12 lines long, less than a line broad, not twisted near the base, bisulcate and somewhat glaucous on the lower (outer) side, short-pointed, obtuse or slightly emarginate, those on the lower branches 2-ranked and spreading, those on the upper scattered, crowded, and more or less appressed, shorter on fertile than on sterile branchlets; cones 2½ to 3 inches long, 1½ to 2 inches thick, solitary, erect, ovate or oblong, obtuse, greenish; scales 6 to 10 lines long and about as broad, horizontal and close-pressed, broad-cuneate, unguiculate, the rounded upper margin somewhat reflexed and resinous, pubescent; bracts short, white with a dark base,

erose-dentate all round, their slightly elevated summits furnished with a strong mucro; seeds large, the wing covering nearly the whole surface of the scale; sterile aments 2 inches long, 3 lines in diameter, marked longitudinally and somewhat spirally by the dark centres of the otherwise light brown mucronate scales.

78. The Local Distribution of Plants and the Theory of Adaptation

History.—Written Jan. 8 to Feb. 7, 1875. This was my first magazine article. I sent it to Dr. E. L. Youmans on Feb. 8, 1875, with many misgivings. The manuscript was formally acknowledged, but I heard nothing more from it for eighteen months. Meantime I had revised and considerably enlarged it from my rough draft, and read it on March 29th before the Potomac Side Naturalists' Club. There the matter rested, and I supposed the article sent had long since found its way into the waste basket, when on July 25, 1876, in acknowledging another article, which the fate of the first had not deterred me from sending to the same magazine, I was informed that this one was in the hands of the printers and would probably appear in the September number! I received proof of it on Aug. 15th, and the October number in which it appeared reached me on Sept. 18th. I am still using the principles set forth in this article, and applying them to sociological theory (see *Applied Sociology*, p. 124).

The Popular Science Monthly, New York, Vol. IX, October, 1876, pp, 676-684.

THERE is one class of facts in the geographical distribution of plants which has not received, at the hands of botanists, the degree of attention which its importance justifies.

I do not refer to those wide general phenomena which a comparison of the floras of different countries renders so striking, and by which the more humble and restricted class to which I would call attention is usually eclipsed. Such general considerations are, it is true, exceedingly interesting and important, and are in no danger of receiving too much attention. Nothing could be more absorbing than a close comparative analysis of the vegetation of different hemispheres, continents, islands, and zones, of the globe. The most casual survey of such fields reveals marvels, the mere acquaintance with which excites in the mind of the botanist the liveliest interest and pleasure. The strange and leafless euphorbias of South Africa, with their naked, green, parenchymous branches; the equally singular and grotesque cactuses of America answering to them; the anomalous vegetation of Australia, with its shadeless forests due to their vertical foliage; the absence of oaks east of the Ural Mountains, and of heaths on this side the Atlantic; the confinement of the genus *Rosa* to the northern and of the genus *Calceolaria* to the southern hemisphere—these and numberless other kindred facts connected with the general distribution of plants over the globe are justly calculated to excite the most intense interest, and have given rise to a variety of theories designed to account for them.

The phenomena, however, to which I would more particularly refer, come much nearer home, and may be presumed to have attracted the attention, more or less forcibly, of every one at all conversant with plants. They constitute a distinct class, and may be described in general terms as facts unfavorable to the received theory of adaptation.

It has long been regarded as a law of life, applicable alike to animal and vegetable forms, that each species is exactly adapted to the particular habitat where it occurs; and naturalists, assuming this law, | have 677
sought to solve the problem how this remarkable adaptation has been brought about, instead of pausing to question the alleged law of adaptation itself. And yet there have never been wanting numerous and obvious facts, especially in the vegetable kingdom, which, if interpreted at all, must be conceded to be incompatible with such a law, at least unless materially modified and greatly enlarged.

Mr. Thomas Meehan has remarked the fact that "almost all of our swamp-trees grow much better when they are transferred to drier places, provided the land is of fair quality. He referred, among others, to sweet-bay, red maple, weeping-willow, etc., as within his own repeated observations growing better out of swamps than in them." He further observes that "plants as a general rule, even those known as water-plants, prefer to grow out of water, except those that grow almost entirely beneath the surface."[1]

A great many facts are at hand to prove that those plants which are found habitually growing in wet ground may be easily made to grow in dry ground. The *Iris versicolor* (blue flag), which, in a state of Nature, grows universally in marshes, and keeps perpetual company with *Nuphar* (pond-lily) and *Sagittaria* (arrow-head), is a common occupant of the driest gardens. The *Lobelia cardinalis* (cardinal-flower), which I have found below tide-water mark, is also a common garden-flower, and not difficult to cultivate. Almost as much may be said for *Lobelia syphilitica* (great lobelia). The calla, the caladiums, and the anthuriums, belong to this class, and the list might be indefinitely extended.

But differences of moisture in the soil are not the only ones which are often overcome by natural or artificial

[1] *See* POPULAR SCIENCE MONTHLY, for May, 1874, p. 126.

changes in the conditions of growth. Most of our prettiest wild-flowers which are found growing in deep, shaded glens in pure leaf-mould, have been captured by florists, and made to thrive as well, and often better, under a cultivation which, with their most faithful efforts to imitate it, must be a complete alteration of their native condition of life. Of such might be mentioned at random the *Trillium* (wake robin), the *Cypripedium* (lady's-slipper), the *Dicentra* (Dutchman's breeches), the *Uvularia* (bellwort), the *Erythronium* (dog's-tooth violet), etc.

So, too, plants growing under other conditions, as on hillsides, and in open woods or meadows, as the violets, hepaticas, anemones, and others, offer no difficulty to the florist.

These are cases in which the transfer is from apparently more favorable conditions to those less favorable. But similar results follow from a reversal of this order. Plants may be successfully transferred to ordinary garden-soil from localities which we would naturally suppose to be less favorable to growth, but to which these seem to be specially adapted. The columbine (*Aquilegia*), which grows on rocks, often with scarcely any soil in which to root, or
678 emerges from narrow | crevices between them, is planted in gardens where it thrives equally well. The same is true of the *Cacti*, which, taken from the arid plains where their indurated watery stalks and branches store up the water which the climate so long denies them, thrive under cultivation with undiminished vitality. The *Agave*, or American aloe, furnishes a similar illustration, and every few years a gorgeous century-plant blooms under cultivation, to the infinite delight of its owner.

Equally striking results take place under the influence of man without his design or selection. There are a great many indigenous plants which are rarely found outside of the influence of human cultivation. They emerge from their obscure natural retreats at the approach of civilization, spread rapidly over fields and pastures, and often become

formidable enemies of the farmer and the gardener. Under the general name of weeds they are proscribed and pursued. and no effort is spared for their extermination. They also invade towns and cities, overrun vacant lots, disfigure parks and plats, and force themselves into pavements and "crannied walls." *Ambrosia trifida* (the great rag-weed) forms forests in waste grounds and neglected gardens, *A. artemisiæfolia* (Roman wormwood) is one of the farmer's most persistent pests, and resists all efforts at extermination. The cocklebur and thorny clotbur (*Xanthium strumarium* and *X. spinosum*) warn us of their disagreeable presence wherever we go. *Polygonum aviculare* (knot-grass) and other species invade our door-yards and threaten to cross our thresholds. *Euphorbia maculata* (spotted spurge) spreads its prostrate and symmetrical mats over the dry and gravelly walks. *Spergularia rubra* (sand spurrey) unfolds its rosy petals to the hottest July sun upon the parching bricks beneath our feet. *Erigeron Canadense* (horse-weed), *Epilobium angustifolium* (great willow-herb), *Gnaphalium polycephalum* (common everlasting), and a host of other indigenous weeds, overrun the cultivated fields and commons wherever man has impressed his influence upon primitive Nature.

This phenomenon, however, becomes still more obtrusive when we turn to introduced species. And, if it be claimed that the transfer from waste places in the Old World to similar waste places in the New is not a change of conditions, we have only to remove our point of observation to Europe or Asia to render all that has been said of indigenous plants applicable also to adventive ones. For, unless we are willing to go further in admitting the transmutation of species than the founders of that doctrine, we must assume that each of these species has had a native habitat somewhere, and its preference for proximity to human habitations is unexplainable on any theory of original adaptation.

Illustrations on this point would be quite superfluous, as these plants constitute the bulk of all our weeds, and

present themselves at every turn. I might mention the
679 ubiquitous ox-eye daisy (*Leucanthe | mum vulgare*), the iniquitous Canada thistle (*Cirsiumarvense*), and the obnoxious burdock (*Lappa officinalis*), as examples of species which share with man, not only his cosmopolitan character, but also some of his vices. But these foreign immigrants often furnish us with one of the most striking exemplifications of the anomaly, if such it may still be called, which I am endeavoring to illustrate.

It frequently happens that a plant, taken from one country into another having an entirely different flora, thrives more vigorously than it did at home, and even threatens to drive out indigenous species. Some of the species last mentioned belong to this class, particularly the Canada thistle, which, notwithstanding its popular name, has been introduced into this country from Europe, and has spread not only over Canada and New England, but far south and west. *Cnicus lanceolatus* (common thistle) is only less prominent because less troublesome. The same is true of many plants of the mint family, particularly *Nepeta glechoma* (ground-ivy). On the other hand, some American species, like *Erigeron Canadense*, have migrated by the aid of man into almost every country on the globe, always thriving best where civilization is highest. But some of these do not confine themselves to the circle of man's protective influence. Sometimes they strike out into the forest or spread over the plains, carrying dismay to the native vegetation. Mr. Darwin, speaking of the introduction into South America of the cardoon (*Cynara cardunculus*), a congener of the artichoke, says: "It occurs in these latitudes on both sides of the Cordillera, across the continent. I saw it in unfrequented spots in Chili, Entre Rios, and the Banda Oriental. In the latter country alone, very many (probably several hundred) square miles are covered by one mass of these prickly plants, and are impenetrable by man or beast. Over the undulating plains, where these great beds occur, nothing else can now live.

Before their introduction, however, the surface must have supported, as in other parts, a rank herbage. I doubt whether any case is on record of an invasion on so grand a scale of one plant over the aborigines."[1] He also mentions other analogous cases, though of a character less marked.

This love of change, if I may so characterize it, seems to inhere in the entire vegetable kingdom. Not even climate avails to overcome it, as is evidenced by the rapid invasion from the tropics of many plants whenever the presence of man in any manner creates the conditions favorable to their migration. Conspicuous among these are *Chenopodium* (pigweed), *Amarantus* (amaranth), *Ipomœa* (morning-glory), and others.

If we take a wider view of this class of phenomena, we may perceive that it is only by an extension of the same principle that all the beneficial changes made by man in the vegetable kingdom have become possible. Every plant he has improved and rendered subservi | ent to his purposes has become what it is in obedience 680 to an inherent tendency to exchange its original condition for a better one. And it is by taking advantage of this tendency and creating such better conditions that man has drawn it into his service.

This willingness and often eagerness in plants to change their habitat, sometimes without the least acclimation, enlarges, therefore, from the mere *lusus naturæ* which it at first appeared to be, into a law which is coextensive with plant-life. In view of the facts adduced, and others which will occur to the reader, we may conclude that the law of adaptation as popularly held requires extensive qualification if allowed to stand at all; that it is rather apparent than real; that large classes of facts are marshaled against it, and that some wider law is perpetually overruling it. The adaptations of Nature of which we hear so much are *not* perfect. Nature does not provide each species with a habitat best suited to its fullest development. But every plant

[1] "Naturalist's Voyage round the World," p. 119.

is at all times ready to change its habitat for a better one, and this is actually going on whenever occasion permits.

Let us now inquire whether the facts enumerated admit of any general explanation. Mr. Meehan proposes to account for the better growth of swamp-trees in drier soil by maintaining that their seeds cannot germinate in dry ground. If this be true, it is a worse commentary on the theory of adaptation than I am willing myself to make without further proof. Certainly no intelligent adapting power could originate so gross and apparently gratuitous an inadaptation as an organism doomed to live out its existence under conditions unfavorable to its healthy development, because, forsooth, it could *begin* its career only under such conditions! But, as both the theory and the commentary rest on a teleological basis, they are both worthless from a scientific point of view.

But, however this may apply to the trees enumerated by him, it certainly does not apply to many plants of the same class which I have named, for florists propagate them from the seed when they choose. Still less can this explanation be admitted to account for any of the other classes from which illustrations have been drawn. And, indeed, I am not aware that any attempt has ever been made to bring forward a rational explanation of a general character for the facts under consideration. Botanists, generally, seem to have been either too much dazed by the light of those more universal and striking features to which attention was called at the outset, or too intent on the special study of the facts themselves, independent of the lessons they inculcate, to have worked out a solution for the problem I have been seeking to present. But the chief obstacle, after all, to such a solution, is to be found in the satisfaction which every one seems to feel with the old explanation, viz., that plants grow in particular places because they are adapted to them and to no other, which, as we have seen, is opposed by a strong array of facts.

681 | In this theory of perfect natural adaptation, whether it be left to stand upon its old teleological basis, or be placed, as some modern investigators would place it, upon a genetic one, a very important factor has been left out, viz., the influence which plants exert upon one another. Adaptation, as the term is employed, is applied to a supposed correlation between the plant and its *inorganic* environment; and to this alone is attributed their entire local distribution. But facts of the class above considered prove that this is not only an inadequate explanation of such distribution, but that it is in many cases no explanation at all, since they so generally disregard inorganic conditions, and thrive equally well or better under entirely different ones from those which Nature furnished. Their distribution must, therefore, be almost entirely attributed to some other conditions; and to what other conditions are they subjected but to organic ones, to those which they reciprocally impose upon each other? It is to these organic conditions, then, to the mutual influence of different kinds of vegetation, growing, as it always does in a state of Nature, in close local proximity and contact, that we must look for the chief laws that control the local distribution of plants.

The modification, therefore, of the adaptation theory, or rather the substitute for it, which, in the light of these facts, I would propose, might be called the law of *mutual repulsion*, by which every individual, to the extent of its influence, repels the approach of every other and seeks the sole possession and enjoyment of the inorganic conditions surrounding it—this mutual repulsion results at length in a *statical* condition which is always brought about through the action of the vital forces themselves, and which, as soon as reached, determines absolutely the exact place and degree of development of each species and each individual.

It is this statical condition which is apt to be lost sight of in the modern philosophy of evolution. The modification of species, the survival and advancement

of some and the depauperating and extinction of others, all forms of variation and transmutation—these are *dynamical* phenomena, and only take place under the influence of disturbing agencies. Changes of this kind are slow and secular, and lie beyond the reach of direct observation, perceptible only to the eye of reason on the closest comparison of large masses of dependent facts. They, therefore, long escaped observation, and Nature remained until recent times a sealed book with respect to them. What wonder, then, that this still deeper and more occult law of biological statics should have remained still longer undetected, or only dimly seen? For, underlying this dynamical movement in organized beings, there must exist a universal statical condition throughout organic as throughout inorganic Nature.

The changes of which science has at length caught a glimpse can be nothing more than the regular and cyclical or fitful and spasmodic | disturbances of a
682 deeper and universal state of forced equilibrium, which pervades the vital as it is known to pervade the mechanical world. And just as astronomers and physicists, confining their investigations to the more obvious and perceptible motions of celestial and terrestrial bodies, long remained ignorant of the law of gravitation which constantly forces all things into a state of equilibrium, so in biology the statical condition has been lost sight of in the effort to obtain better views of that moving panorama which a broader knowledge of the phenomena of life so unmistakably unfolds. Yet, without a clear recognition of this statical law, it is impossible to account for the facts presented by the distribution of plants, and it will doubtless be found equally essential to the full comprehension of many other phenomena of Nature. But, when we recognize this law, the whole aspect of our question is changed. Plants appear to be no longer in a state of perfect adaptation to their surroundings.

There is no longer a necessary correspondence and corre-

lation between organism and habitat, no longer necessary that rhythmical (almost preëstablished) harmony between species and environment. This need only exist so far as is necessary to render the life of the species possible. Beyond this the greatest inharmony and inadaptation may be conceived to reign in Nature. Each plant may be regarded as a reservoir of vital force, as containing within it a potential energy far beyond and wholly out of consonance with the contracted conditions imposed upon it by its environment, and by which it is compelled to possess the comparatively imperfect organization with which we find it endowed. Each individual is where it is, and what it is, by reason of the combined forces which hedge it in and determine its very form. Each species is the perpetual and inexorable antagonist of every other. The "struggle" is not alone "for existence," it is also for *place*. In the plant races, as in the human, there is a recognized hierarchy, the laws of which are as yet to a great extent involved in mystery. But the first principle, as in the rest of Nature, is force. Each one encroaches with all the power of vegetal growth upon its neighbors. This pressure is enormous. Who shall calculate this subtilest of molecular forces? Yet there is no displacement, no motion. So thoroughly has every nook and chink been filled that there is no room for motion. Like the all-pervading circumambient air, its power is not felt so long as no vacuum is produced. Each organism has long since reached the limit of its power to extend its dominion. The plant grows up from the germ to maturity under a constant surveillance, and every attempt to overstep its fixed limits is instantly checked. It stands in its fixed position, locked in the embrace of forces which permit it neither to advance nor retreat.

Such is the state of equilibrium which is always and necessarily reached in a state of Nature, and in which man first finds each newly-discovered flora. But let
683 these statical conditions be once changed, | whether by the advent of man or from whatever cause, and this

equilibrium is immediately disturbed. The chained forces are set free; a general swarming begins; some individuals are destroyed, others are liberated; each pushes its advantage to the utmost, and all move forward in the direction of least resistance, till at length they again mutually neutralize each other, and again come, under new conditions and modified forms, into the former state of quiescence.

The most frequent and prominent cause of these disturbances of the natural fixity of vegetation is the influence of man. The results of this influence may be said to be the products of agriculture, horticulture, and floriculture, on the one hand, and, on the other, weeds. But there may be many other causes of disturbance besides that produced by man, such as the appearance of new animals, geological revolutions, or climatal and meteorological vicissitudes. Anything which destroys the stability which the perpetually-operating vegetal forces impose upon the plants of any region is certain to reveal a latent vitality, which, when liberated, proves itself capable of profiting by conditions far different from, and superior to, those under which it is originally found. The willow, the alder, the elm, and the sycamore, hug the banks of streams because baffled and beaten back at every attempt to invade the drier ground. The wild-columbine and the saxifrage are driven into their rocky fastnesses by more powerful rivals for the rich forest loams. The thistle and the chamomile flourish in lawns and commons because their human foes are less formidable than the enemies of the plain. The fruit-trees, the cereals, and the roses, reach those wonderful heights of development under man's care, because he not only proves their friend, but wards off all their enemies. And just here it should be remarked that the alleged tendency of cultivated plants to relapse, when neglected, into their original state, upon which Prof. Agassiz laid so much stress as an unanswerable argument against transmutation, becomes, under the law of mutual repulsion, the necessary result of remanding them

to their old conditions. As man's care and protection were necessary to enable them to advance, so, when these are withdrawn, they must be expected to again yield to hostile forces, and fall back to the level of their original state. It is not the special adaptation of a plant for the spot on which it grows, so much as the hostile attitude of other plants around it, which restricts and determines its range. The elements which decide where plants shall grow, are to be found in vegetation itself, and not in inorganic conditions. The power of self-adaptation which they possess is sufficient to habituate almost any species to almost any inorganic conditions. Each species, therefore, keeps within its own restricted limits, not because it cannot live in other soils, but because prior occupants forbid it to come.

The law of adaptation may therefore be reduced to this: that every plant possesses the power of self-adaptation to such a degree | that, no matter under what con- 684
ditions it may be compelled, by the higher law of mutual repulsion, to live, it will mould its own organism into harmony with those conditions, and thus continue its existence; and this, whether it is required to adopt a more perfect or a less perfect form.

But what it actually is, is no criterion of what it is capable of becoming, and the locality in which it is found is no evidence that it is best adapted to such a locality. These data only prove that in the final balance of forces to which it is subjected it was assigned such a degree of development and such a habitat.

November (?), 1876—Ætat. 35.

79. Tipularia discolor

History.—Written July 22, 1876. Being intended for the column of notes, I wrote it in the third person.

Field and Forest, Washington, D. C., Vol. II, No. 4, October, 1876, pp. 66–67.

MR. L. F. WARD of the Naturalists' Club has succeeded this season in discovering a locality where an abundance of this rare and interesting Orchis can be obtained in the flowering state. As is well known to the members of the Club, this plant is common enough during the season of the year when the 67 con | spicuous root-leaf is on; the difficulty has been to find it in its flowering condition, which does not occur until long after every trace of the leaf has disappeared, and careful observation has proved that it is only under peculiar circumstances that it blooms at all, so shy and coy does it appear to be. And when it does send up its brown scape so near the color of the leaves through which it peers, and open its brown-purple flowers with scarcely a different hue, it is a rare chance if any botanist happens to detect it during the brief period of its evanescent existence in this state.

For several years Mr. Ward, Prof. Doolittle, and Mr. J. M. Comstock of this city, have carefully watched the

phases of this plant and marked with the greatest care all the principal localities where it is found in this vicinity, but have heretofore only succeeded in securing enough flowering specimens to supply the local demand. The new locality and from which they hope to supply exchanges, is on the Virginia shore of the Potomac not far above the Three Sisters. The exact time for collecting it in flower seems to be the last week in July.

80. A Party can perpetuate its Rule. Dangers of throwing out a State's vote in any case

History.—Written January 15, 1877. I put my initials, L. F. W., to this, and it so appeared.

The Daily Tribune, New York, Vol. XXXVI, No. 11,174, January 20, 1877, p. 2.

To the Editor of the Tribune.

Sir: In today's issue of THE TRIBUNE you editorially say: "All the light that intelligent discussion can shed upon the Presidential question is welcome." Permit a suggestion which, it is believed, has not yet been distinctly presented. The letter of the Constitution is admitted to cover no such case as the present. All that can be appealed to is its spirit. The question is: Does the spirit of the Constitution favor the theory of the power of Congress to reject the vote of a State returned in accordance with the laws of such State? If so, see what may result. If either house can do this, then a case may easily arise in which the two houses, being of different political complexions, as at present, may proceed to throw out States on a strife to secure the Presidency and disfranchise half the country. If it requires the concurrence of both houses to throw out the vote of a State, who does not see that if both houses are of

the same political complexion, as is usually the case, the dominant party has the power to thus perpetuate itself? Even could a State's vote be rejected by a regular resolution or law to meet the case (*ex post facto*), signed by the President, the party in power would still possess the means of perpetuating its rule. Must we then depend upon the disinterested patriotism and judicial statesmanship of the Representatives of the people in Congress to magnanimously admit their opponents, who may have a bare majority in the Electoral College, when they have the power to keep them out? The question is: Does the spirit of the Constitution favor the right of the party in power to so reduce the votes of the Electoral Colleges as to perpetuate its own supremacy?

WASHINGTON, January 15, 1877.

81. A Perpetuated Oligarchy

History.—Written January 18, 1877. This was not intended for publication. There was an editorial in the *Tribune* of that date taking the same ground as my previous note, and I wrote a letter to Whitelaw Reid congratulating him on it. This is a part of that letter to which my full name appears.

The Daily Tribune, New York, Vol. XXXVI, No. 11,175, January 22, 1877, p. 5.

To the Editor of the Tribune.

Sir:—Allow me to congratulate you and THE TRIBUNE on having at last sounded the alarm. The editorial in to-day's TRIBUNE, entitled "Revolution on Two Wheels," contains the words of a statesman and not of a politician. I had looked long and anxiously to see them uttered, and had begun to fear that in all our land there was not one voice that would be raised against the only real "revolutionary conspiracy" that is being enacted—a conspiracy in the name of compromise and peace (!) to make this Government a perpetuated oligarchy.

What little attention I give to political affairs is from a national point of view, and I cannot suppress my deep solicitude when I see a joint committee of mere tinkers trifling with the very abutments of the national structure,

and proposing to convert an election into a lottery. May THE TRIBUNE continue to thunder against this weak and dangerous proceeding until the whole country shall be aroused to its insidious perils.

WASHINGTON, January 18, 1877.

February (?), 1877—Ætat. 35.

82. A Congress of Birds

History.—Written November 13, 1876 (so dated), from observations made the preceding day.

Field and Forest, Washington, D. C., Vol. II, No. 7, January, 1877, pp. 122–123.

THE congregation of different species of birds in one place for mutual protection and perhaps for company, is not an uncommon phenomenon, but I have never seen it more clearly exemplified than on yesterday. I had been roving about for several hours through the many finely wooded tracts that line the banks of Rock Creek in the vicinity of Washington and Georgetown, and was remarking the uncommon silence and absence of life that reigned there, when suddenly I came upon what seemed a flock of birds. Some were in the trees, others on the ground or on logs, and moving about among the scanty underbrush. Supposing them to be all of one kind, I hastened to determine what birds they were. The first ones identified were Robins, but I soon observed that there were others that were smaller. These I saw to be Bluebirds; then I espied some crests and was able to approach near enough to several Cedar-birds to see the wax on their wings; rustling among the dried leaves near by were a number of Hermit Thrushes (*Turdus pallasii*); numerous Snow-birds next made themselves obtrusive, as also one

Sparrow; hopping about on the trunks of the trees were plainly seen three or four Woodpeckers (*Sphyrapicus varius*). These were all I was able positively to identify, but there were reasons for thinking that still other species
123 | were keeping the same company. Thus had at least seven wholly distinct species of birds, belonging to widely separate families and orders, huddled together in one spot, while the rest of the woods presented the utmost stillness and lifelessness.

November 13, 1876.

83. Evolution in Biology and Philology

History. — Written February 12, 1877. This article grew out of a conversation with Major Powell about language, in which I thought he confounded unlike principles. It took a strong hold of me then, because I wrote in my diary that I "spent most of the day writing out and copying off a statement of the cause of the confusion of the terms general and special in biology and philology. Think I have cracked that nut." My rough draft is preserved. My initials only were appended to this article.

The Evolution, New York, Vol. I, No. 7, March, 1877, p. 97

THE phenomena of the development of language and of organic forms are strictly parallel, but a confusion exists in the use of the terms *general* and *special* by biologists and philologists.

In *biology*, starting from the lowest organism, there is a gradual differentiation of organs and functions from a condition in which a single organ performs all the necessary functions of life, but performs them very imperfectly, to one in which many distinct functions are performed by as

many definite organs which perform no others, but perform these well.

In *philology*, starting from the holophrase, or sentence-word, considered as an organ expressing many ideas, but expressing them very imperfectly, there is a gradual differentiation of terms and conceptions from the condition in which one term badly expresses many conceptions to one in which many distinct conceptions are expressed by as many definite terms which express no others, but express these clearly.

Thus the analogy, or rather the *homology*, is complete. The confusion arises from the simple fact that in the nature of thought, of which language is merely the exponent, general and abstract ideas which arise with the evolution of mind, necessitate the introduction of corresponding general and abstract terms. These form, it is true, but a small part of the vocabulary of even the most advanced races. The greater part of the definite terms resulting from differentiation are not abstract, but concrete and apply to particular objects (nouns), actions (verbs), attributes (adjectives), and conditions (adverbs). To consider general terms as among the specialized products of differentiation is simply a paradox. There are two distinct kinds of specialization, the one *phenomenal*, the other *logical;* the one passing from the homogeneous and indefinite to the heterogeneous and definite, in *real things;* the other passing from the abstract and general to the concrete and particular, in *thought.* These two processes are wholly independent of each other. The first is properly called *differentiation*, the second *classification.*

The application of the terms general and special to both classes is what has led to the confusion. Both methods are employed in both sciences.

Differentiation is, as above shown, identical in both. Classification in natural history is a temporary ignoring of the strict facts of differentiation, and a resort to imaginary abrupt differences, a mere logical device for the convenience

of study. Classification of ideas, or generalization, is the same process applied to all objects, and enters into language by requiring the adoption of terms of different grades of generality.

The development of such general terms to denote general conceptions does not deprive these terms of their definiteness as products of differentiation, since definiteness, in this sense, is simply adaptation or *limitation* of term to conception. Thus arises the apparent contradiction that in the development of language many of the so-called *special words* are *general terms.* This is indeed true, but the terms special and general as here employed are not only not antithetical, but they apply to two distinct kinds of classification, resting on wholly different bases, and independent of each other throughout their entire course. A general term is a specialized product of differentiation from a state in which general and special conceptions were confounded under one indefinite, homogeneous holophrase. The congeries of ideas imperfectly expressed by this low undifferentiated word has unfolded, and a special word has been assigned to each distinct idea. Because one or more of these ideas chances to be a *general* one does not deprive it of its *special* word to denote this idea. This kind of specialization in which one word is limited to one idea, and one organ to one function, stands of course, in no logical relation to the classification of words according to the degree of generality of the ideas they are designed to express.

The confusion has been altogether due to the ambiguity of the terms general and special, and when our advanced languages shall have become still further differentiated so as to render such ambiguity as still lurks even in their scientific terms no longer possible, there will no longer exist the confusion of ideas to which it gives rise. As a step in this direction it would undoubtedly be a gain to science if these terms special and general could be restricted to the logical process of classification where they clearly belong, and other words be adopted for the cosmical process of dif-

ferentiation; for while it may not appear incorrect to characterize the *differentiated* as *special*, there is an obvious impropriety in making the *undifferentiated* synonymous with the *general*.

84. Earthworms on the Pavements

History.—Written March 20, 1877. There were some answers to this, noting the occurrence of earthworms on the asphalt pavements, and I afterwards observed such cases myself. The word "instinctively" in the last sentence was misprinted "instructively."

Field and Forest, Washington, D. C., Vol. II, No. 10, April, 1877, pp. 183–184.

ON Thursday morning, March 15th, great numbers of the common Earth-worm (*Lumbricus terrestris*, L.) were seen lying scattered about on the pavements of all the streets of Washington. They were dead and presented a somewhat shrivelled appearance. They were of all sizes and lay in all positions, on the brick walks and stone flaggings wherever one chanced to look. As the weather was freezing cold they were of course frozen stiff. I counted over a hundred, some of a very large size, in walking the length of the U. S. Treasury Building, lying about upon the broad flagstones that form the walks around it. It will be remembered that the weather on Wednesday was mild and rainy, and during the early part of the night a heavy fall of rain occurred, followed by a high

wind and a fall of temperature to considerably below the freezing point. We may presume that the ground, already saturated with moisture, became so wet during the heavy rainfall that the | worms could no longer exist below the surface and crawled out in immense numbers. Reaching the surface they travelled about in all directions, perhaps in search of drier places than were afforded by the sod and grass of public parks and open ground. They thus found themselves on the pavements when the change came and succumbed to the increased cold and sharp drying wind. 184

Singularly enough, none were to be found on the asphalt pavements of the streets, or even on the walks of that material passing through certain parks. May it not be that their senses warned them of the presence of this bituminous substance, which, proving disagreeable to them, instinctively turned them away from it as soon as reached in their wanderings?

85. Haeckel's Genesis of Man, or History of the Development of the Human Race

History.—Sometime in January or February, 1876, I learned of the existence of Haeckel's *Anthropogenie*, the first edition of which appeared in 1874. A certain book agent, Muralt by name, had imported Comte's *Philosophie Positive* and other books for me, and I asked him to send for this. It arrived on March 7th, but I did not commence reading it till April 1st, or almost immediately after having finished reading the six volumes of Comte. I finished reading the *Anthropogenie* on June 12th, but as soon as I commenced it I perceived that I should have first read the same author's *Schöpfungsgeschichte*, the first edition of which appeared in 1869, if not his *Generelle Morphologie*, 1866. I immediately ordered these, but the latter was out of print. The other arrived, however, just as I was finishing the first. It was the fifth edition of 1874, revised since the appearance of Darwin's *Descent of Man*, 1871. This review, written from June 15th to August 24th,

which purports to be of the *Anthropogenie* only, was therefore written in the light of both works. I sent the first article to the *Popular Science Monthly* as soon as finished, on July 1st, and followed it up with the second, July 21st. It was soon after this, viz., on the 25th, that I received notice that my article on the *Local Distribution of Plants*, which had been so long in their hands, was in type and would soon appear, but on August 15th I received a letter from Dr. E. L. Youmans saying that they already had an excess of biological matter, and it would be impossible to give space for my articles on Haeckel. I confess that I had not much expected that they could stand such a deluge. The last one was completed on August 24th.

I was on intimate terms with Mr. Henry Ulke, the great portrait painter and coleopterist, whose death at eighty-nine years has so recently (February 17, 1910) occurred, and I had informed him that I was writing an elaborate review of Haeckel's work. He invited me to bring the manuscript to his house and read it to him and the family. Mrs. Ulke was then living, a most charming and cultivated lady, and Mr. Joseph Lyons, a scholarly Hungarian, was living with them. Several evenings were spent in reading and discussing the articles, a most enjoyable episode.

The question of publication lay long in abeyance. The matter was so voluminous that it was not adapted to any periodical then being published, and the popular magazines were out of the question. I did not even offer it to any of them. Finally,

early in December, Major Powell, who knew what I had written, advised me to try the *Penn Monthly*, published in Philadelphia. I did so, and the articles were promptly accepted, of course "without compensation," but little I cared for that. They ran through the three numbers, April, May, and July, 1877, the last one appearing on July 7th. There the matter rested for a year and a half.

I of course sent copies of the *Penn Monthly* containing the articles to Professor Haeckel, and on receipt of the last one he wrote me the following letter, of which I was naturally very proud:

JENA, 24 Oct. '77.

HOCHVEREHRTER HERR!

Schon seit Monaten habe ich Ihnen meinen herzlichen Dank für die überaus wohlwollende und verständnissvolle Besprechung meiner Anthropogenie sagen wollen, welche Sie im "Penn Monthly" haben erscheinen lassen, und welche Sie die Güte hatten, mir zu übersenden. Ich danke Ihnen aufrichtigst, nicht im Interesse meiner Person, sondern im Interesse der Sache, welcher ich diene . . . Beifolgend sende ich Ihnen meine Photographie, mit der freundlichen Bitte, mir dafür die Ihrige zukommen zu lassen.

Indem ich hoffe, dass Sie der Entwickelungslehre Ihr warmes Interesse bewahren und auch mir Ihr freundliches Wohlwollen bewahren werden, bleibe ich mit wiederholtem Danke, in vorzüglicher Hochachtung

Ihr ergebenster
ERNST HAECKEL.

I sent my photograph to Professor Haeckel, as he requested. He had sent me, as stated in the parts of the above letter which I have here omitted, several of his minor works, and he has continued

from that time to this to send me the successive editions of the *Anthropogenie* and *Schöpfungsgeschichte*, his numerous addresses, and his latest works (*Welträthsel*, *Lebenswunder*, *Generelle Morphologie*, abridged edition of 1906, and even the English [American] editions of his popular works), and I, of course, have sent him practically all my subsequent writings. Our correspondence has been highly interesting, and in 1894 I had the great pleasure of meeting him *in propria persona* on top of the Uitliberg above Zürich (see No. 560).

The *Penn Monthly* had a limited circulation and not chiefly among scientific men, and I began to be desirous of placing my review before a larger and better selected audience. Accordingly in January, 1879, I conceived the idea of republishing the three articles in a brochure. I corresponded with the publishers of the *Penn Monthly*, which had changed hands in this respect, and learned that the type would have to be reset and all done anew. But the cost was not excessive, and I arranged to have it done and an edition of 1000 copies printed. This plan was carried out, and the pamphlet was issued on April 24, 1879. The publishers, Messrs. Edward Stern & Co., undertook to sell the edition at a fair price and satisfactory division of the proceeds. I distributed 100 copies gratis to my friends and correspondents. A fire occurred in the office in July and destroyed nearly 400 copies. The rest were sold during the remaining four years. The sale of the edition was greatly accelerated by the active interest of Mr.

Thaddeus B. Wakeman of New York, an accomplished German scholar and liberal-minded man, who lectured on Haeckel before the Brooklyn Ethical Association and throughout the country, and never failed to draw the attention of his audiences to my pamphlet. On March 1, 1895, I was obliged to recall a small remnant of the edition to prevent the pamphlet from becoming unobtainable. Of these there now remain only a very small number.

In preparing the articles for publication in pamphlet form, I revised them carefully and made a considerable number of verbal alterations, but no extensive additions or reductions. In the present work it is this revised text that is used, but both paginations are indicated.

The title-page and preface of the pamphlet were written on February 11, 1879, and these are reproduced here.

The Penn Monthly, Philadelphia, Vol. VIII, No. 88, April, 1877, pp. 266–284; No. 89, May, 1877, pp. 348–367; No. 91, July, 1877, pp. 528–548; Covered reprint, Philadelphia, 1879, 64 pages, 8°.

[1] HAECKEL'S GENESIS OF MAN | OR | HISTORY OF THE DEVELOPMENT OF THE | HUMAN RACE[1] | BEING A| REVIEW OF HIS "ANTHROPOGENIE," AND EMBRACING A | SUMMARY EXPOSITION OF HIS VIEWS AND OF | THOSE OF THE ADVANCED GERMAN | SCHOOL OF SCIENCE. | BY | LESTER F. WARD, A.M. | PHILADELPHIA: | EDWARD STERN & CO. | 125 & 127 NORTH SEVENTH ST.

266 [1] Anthropogenie, oder Entwickelungsgeschichte des Menschen, von Ernst Haeckel, Professor an der Universität Jena. Leipzic, 1874.

[3] PREFACE

THE three papers constituting this little *brochure* were originally contributed to the PENN MONTHLY, and appeared in the April, May, and July numbers of that magazine for 1877.

As the work which it was their more especial object to review has not yet been placed before the non-German reading public, no apology is offered for their reproduction in separate form.

In view, however, of the popular interest which the views of Prof. Haeckel have since called forth, and which seems to be still increasing, it was thought an opportune moment for laying before the general public this condensed exposition of the thought and labors of the great naturalist and philosopher.

It may further interest the reader to learn that Prof. Haeckel has acknowledged, in a private communication to the author, the substantial correctness with which these papers represent his position.

L. F. W.

WASHINGTON, March, 1879.

[*First Paper*]

I

[5] GENERAL HISTORY OF THE DOCTRINE OF DESCENT

IT is no derogation from the epoch-making labors of Charles Darwin to admit that the arguments he has presented in support of his celebrated theory constitute, as it were, but the half of the vast array which the

present state of biological science is capable of marshalling in its defence.

The sources from which the evidences of descent and natural selection must be derived, may be divided into two general classes: *First*, Paleontology, Comparative Anatomy and Osteology, and Geographical Distribution (*Chorology*), *i. e.*, a comparison of the adult forms of animals both living and fossil (*Phylogeny*); and *Second*, the study of embryonic changes and post-natal metamorphoses, or a comparison of undeveloped animal forms (*Ontogeny*). Of these two classes it may be said that the first have been furnished by Darwin, the second by Haeckel. Not that Darwin, either in his *Origin of Species* or in his *Descent of Man*, has wholly ignored the bearing of embryological considerations upon
267 his | theory. In the former work he has devoted seventeen pages of one of his concluding chapters to "Development and Embryology"; the greater part of which, however, is occupied in pointing out the importance of the various kinds of metamorphosis, chiefly as it is observed in insects, amphibians, etc., after birth; only incidentally referring to those more obscure metamorphoses which take place within the egg or the uterus.

He does allude, however, more directly to Von Baer's law, but without designating it as such; and contents himself with quoting the passage, cited also by Haeckel in the preface to the third edition of his *History of Creation* (1870), in which the great Russian embryologist remarks
[6] upon the striking similarity of many em|bryos, so much so that he was quite unable to say to what animals two specimens which he had preserved in alcohol but had neglected to label, really belonged. Still less attention has Darwin paid to this source of argument in his *Descent of Man*. A few lines quoted from Von Baer and from Huxley, on page 14 of Vol. 1, a figure of the embryo of a human being and one of a dog, from Ecker, on page 15, with brief comments, disposes of this branch of his great argument. Almost as much had been said by the author of the *Vestiges of*

Creation, in 1842.[2] It is safe, therefore, to assume that at the time of the appearance of the *Origin of Species* (1859), Darwin had no conception of the real part that the arguments from embryology were destined to play in establishing his doctrine of the development of organic forms. And although in subsequent editions he was able to notice the *Generelle Morphologie*, it is still improbable that even then he had any adequate idea of the powerful ally he was to have in Germany, as the *Natürliche Schöpfungsgeschichte*, and not less the work under review, have proved the p ofessor of Jena to be. It is of the former of these works that Darwin says that if it had appeared before the *Descent of Man* had been written, he would probably never have completed the latter.

Professor Haeckel is no mere disciple of Darwin, profound as is his admiration of him, and unreserved as is his expression of that admiration. His own countrymen have accused him of being "more Darwinistic than Darwin himself," but it is clear that a large part of this difference is in kind rather than in degree, and that he has infused into the developmental philosophy a true | Haeckelian element. It is true that he drew the logical con- 268
clusion from the premises furnished by the *Origin of Species* five years before the announcement of its recognition by Darwin himself in his *Descent of Man*. This conclusion he boldly and forcibly enunciated in the introduction to his *Generelle Morphologie*, published in 1866, and reiterated with still greater emphasis in his *Natürliche Schöpfungsgeschichte*, in 1868. Between this period and that of the appearance of the *Descent of Man*, Haeckel was exposed to the bitterest attacks, not only from the adherents of the Church and the opponents of Darwin generally, but from those adherents of Darwinism in Germany—and they were many—whose conception | of it was limited to the [7]
body of principles contained in the *Origin of Species*. As in that work all reference to the position of the

[2] New York, 1845, p. 150.

human race in the animal kingdom was carefully excluded, thus ingeniously avoiding the shock of prejudice which any such connection would have occasioned, the simplicity, the *naïveté*, and, at the same time, the force of reasoning displayed in it, not only won the immediate assent of all fully emancipated minds, but took a strong hold upon great numbers of liberally educated persons whose independent reflections had not yet carried them wholly out from under the influence of theological conceptions. Among these were many thoroughly scientific men and naturalists, specialists in the various departments of science, whose analytical labors had not left them time for a synthesis of the facts even within their own special branch of research. These accepted the conclusions drawn in the *Origin of Species* without perceiving that other and important ones might and must follow from the same premises. And because Haeckel drew these logical and necessary conclusions, these persons attacked him from all sides, and heaped upon him every form of accusation. Besides the charge above referred to of out-Darwining Darwin, and of going further than Darwin himself would ever sanction, there was added the stronger one that Haeckel knew nothing about true Darwinism. The appearance in 1871 of Darwin's *Descent of Man* placed these anti-Haeckel Darwinians in a most embarrassing situation, silencing many, converting numbers, and driving not a few into the theological camp. But Haeckel emerged majestically from the battle, unscathed and undaunted. To charges of "radicalism" he had simply replied: "Radical thinking is consistent thinking, which allows itself to be checked by no barriers of tradition or of enforced dogma."

269 To | the confused outcry of the theological school and of the anti-Darwinians in general, he did not deem it worth his while to reply. A satirical remark upon this class, however, is worth reproducing, and might be ranked alongside of Darwin's cutting sarcasm, wherein he says that he who scorns to be descended from a beast will

generally reveal his descent in the act of sneering, whereby he will expose his canine teeth. "It is an interesting and instructive circumstance," says Haeckel, "that just those persons are most shocked and indignant at the discovery of the natural development of the human race from the apes, who, in their intellectual develop | ment and cerebral differentiation, are obviously least removed from our common tertiary ancestors." [8]

Both in his *History of Creation* and in his *Anthropogeny*, Haeckel has done a service to the cause of evolution by reviewing, in a fair and disinterested manner, the history of the origin and progress of those ideas which have culminated in the Darwinian theory. Let us glance for a moment at this history.

Passing over the names of Wolff, Baer, Kant, Schleid n, Oken, and Humboldt, in Germany, of Buffon and Geoffroy St. Hilaire, in France, and of Dean Herbert, Professor Grant, Patrick Matthew, Freke, and Herbert Spencer (*Essays, 1852*), in England, all of whom had given more or less definite expression to these progressive ideas prior to the appearance of the *Origin of Species*, it may be remarked that the great conception of the natural relationship (filiation) of all organic forms and their descent or development from common ancestors that have existed in more or less remote periods of the past, had a threefold independent origin in the minds of three men who were contemporary at the close of the last and the beginning of the present century, in each of the three great nations that now lead the intellectual world. These men were Erasmus Darwin, grandfather of the illustrious Charles, in England, Wolfgang Goethe, the great poet and philosopher, in Germany, and Jean Lamarck, in France. Wholly unacquainted with each other and with each other's works, these three men, almost at the same time, gave utterance to substantially the same fundamental ideas, and elaborated in more or less extended and systematic form the essential ground-principles which now underlie the edifice of all progressive biological science.

In his work entitled *Zoönomia*, published in 1794, Erasmus Darwin lays great weight upon the transformation of species of animals and plants through their own activities
270 of life and | through forced habituation to changed conditions of existence. It is a current remark, as applied to Charles Darwin, that he furnishes in himself one of the finest illustrations of "development," and thus of the truth of his own theory, that can be cited. Far more pointed, however, is the pleasantry of Haeckel, when, referring to the grandfather of Charles as entertaining the germs of his grandson's philosophy, and noting the striking circumstance that his father, though a respect-
[9] able physician, exhibited no signs | of having inherited these intellectual characteristics, he cites the case as a good example of "atavism," and remarks that "Erasmus Darwin transmitted, according to the law of latent inheritance, definite molecular motions in the ganglion cells of his cerebrum to his grandson Charles without their manifesting themselves in his son Robert."

The importance of Erasmus Darwin's views, however, mixed as they were with some vagaries and unbalanced speculations, was slight as compared with that which we must ascribe to those of Goethe. In his various essays and writings on "Natural Science" in general (1780), on Comparative Anatomy and Osteology (1786), on the Metamorphoses of Plants (1790), and in later works, he has wrought out a philosophy of organic life, which, when carefully analyzed and translated into the terminology now adopted, is found to contain, in their most general and fundamental form, the essential principles of the Darwinian theory of development. A few passages will illustrate this. In 1706 he wrote: "All the more perfect organic natures, under which we see fishes, amphibians, birds, mammals, and, at the head of these last, man, are formed according to one original type (*Urbild*), which in its durable parts only deviates more or less, and is still daily being improved and transformed through propagation." It is from this and

other passages in which Goethe establishes his doctrine of an original type or image, which varies only slightly and in detail and not in plan, that the modern adherents of the theory of fixed types seem to have derived their chief arguments. Cuvier must have been conversant with Goethe's scientific writings, and he may have drawn largely upon them in founding his celebrated system of classification. But like some other great works that have become authority, those of Goethe are found, in some things, to admit of two interpretations, and to supply texts looking more than one way. The above passage, taken in connection with others, is now seen still | more clearly to give countenance to what is now the powerful [271] rival of the doctrine of types: viz., the doctrine of descent. In another place he says: "An internal original community (*Gemeinschaft*) lies at the bottom of all organization; difference of form, on the contrary, arises from the necessary relations to the external world, and we may, therefore, with right assume an original, simultaneous variation and an incessantly progressive transformation, in order to comprehend the at once constant and deviating phenomena."

| To further explain this paradox he assumes two independent forces or impulses, working harmoni- [10] ously together in nature, an internal formative impulse (*innerer Bildungstrieb*), and an external formative impulse (*äusserer Bildungstrieb*). The former of these he also, in different passages, designates as the specific force (*Specificationstrieb*) and as the centripetal force; the latter, on the other hand, he calls the modifying force or impulse of variation (*Variationstrieb*), and the centrifugal force. He also uses the term metamorphosis in a general (phylogenetic) sense as applied to the changes that take place in species and genera rather than in individuals. The following passage contains the kernel of this entire portion of his philosophy: "The idea of metamorphosis is like that of the *vis centrifuga*, and would lose itself in infinity were there not a check offered to it; this check is the

specific force (*Specificationstrieb*), the stubborn power of permanency (*zähe Beharrlichkeitsvermögen*) of whatever has once become a reality, a *vis centripeta*, which in its deepest foundations can possess no externality."

If, now, we translate Goethe's internal formative impulse, specific force, or centripetal force, by the modern term *heredity*, as we undoubtedly may, and his external formative impulse, modifying force, or centrifugal force, by the modern term *adaptation*, as we may still more clearly do, we shall have, in Goethe's philosophy of life, neither more nor less than the essential elements of the modern doctrine of descent.

Of course, nothing is here found but the general principles; the mode and the examples could not have been furnished in Germany when Goethe wrote.

Haeckel, however, is abundantly justified in pointing to Germany's greatest genius as having long ago given utterance to the most radical of his own doctrines, and that for which he has received the severest animadversions, when, in the passage first quoted, he places man at the head
272 of the mammalian class. And | yet, who had thought of assailing Goethe with the charge of deriving man from the apes!

With almost equal justice does Haeckel claim that, in the following and other passages, Goethe has not only declared the genealogical relationship of the vegetable to the animal kingdom, but has furnished the nucleus of the unitary or monophyletic theory of descent. "When we
[11] consider plants and animals in their most im | perfect condition they are scarcely to be distinguished. This much, however, we may say, that those creatures that now and then appear, having relationships with plants and with animals difficult to separate, perfect themselves in two opposite directions, so that the plant at last glorifies itself in the tree, durable and fixed, the animal, in man, with the highest degree of mobility and freedom."

The ambiguity of Goethe's language is due to the profundity and high generality of his ideas, coupled with a certain poetic vagueness so indispensable to his genius. In the former quality, though not at all in the latter, one is reminded of that profound and comprehensive analysis which, with all the materials of that later date (1866), and with the power of logic characteristic of England's foremost philosopher, Herbert Spencer, in his *Biology*, (vol. 1, ch. xi., and xii.), has made of these same principles; a treatise, I may add, which Haeckel has indeed recognized,[3] but upon which he could scarcely have failed to place more emphasis if he had been thoroughly acquainted with it.

Quite different in method and character from Goethe's contribution to the theory of transmutation and descent was that of Lamarck. Whatever his philosophy may have lacked in profundity, it was not open to the charge of ambiguity. All its shortcomings were amply compensated for by the wealth of illustration and the multiplicity of facts drawn directly from nature, which, as a lifelong naturalist, he was able to bring to its support. In this respect (and this is after all the chief consideration), the now celebrated, though long neglected, *Philosophie Zoologique* is alone, of all the works that had preceded it or were contemporary with it, worthy of a serious comparison with the *Origin of Species* or the *Descent of Man*. And it is certainly a remarkable coincidence and may have for some readers, if no other, at least a mnemonic value, that the *Philosophie Zoologique* and the *Origin of Species* were separated by the space of just half a century, the former appearing in 1809, | the latter in 1859. The interest of this circumstance is still further heightened by the fact that Charles Darwin was born in the year 1809, the same in which the great precursor of his own works likewise issued into the world; as if its subtle influence had wafted across the Channel and breathed its mysterious

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[3] Schöpfungsgeschichte, 5 Aufl. pp. 106, 657.

afflatus into the nostrils of the new-born herald of its principles!

[12] | The dim intimations and scattered glimpses of Goethe and of Dr. Darwin were insignificant in comparison with the lucid illustrations and systematic arguments of the great French naturalist. After so many years of assiduous study Lamarck, as it were, but copied his conclusions from the pages of nature where facts stood forth like letters in a book. Yet none the less credit to his intellect, for was not this same book sealed to his great contemporary, Cuvier, who knew its alphabet equally well? And is it not sealed to many to-day? The truth is that for the first time the causal and essentially rational type of mind had been joined in the same individual with those other qualities which impel to the patient investigation of facts and details; rare combination, so successfully repeated in the intellectual constitutions of Charles Darwin and Ernst Haeckel.

When we compare, from our disinterested standpoint in America, the great *chef d'œuvre* of Jean Lamarck, its systematic execution, its definite, avowed purpose, and its vast array of proofs from the only legitimate source of argument, with the various writings of Goethe containing his views on this subject, arranged with no systematic order, having no well defined purpose, evincing no clear conception of nature's means or methods, and manifesting a comparatively scanty acquaintance with particular cases by which the laws under discussion are to be illustrated, we cannot fail to perceive, in the circumstance of Haeckel's placing his own countryman before the son of a rival nation, in his estimate of the relative labors of the two pioneers of evolution, a trace of that almost inevitable national bias which lurks in regions of the brain inaccessible to the invasion even of exact science. The essential incongruity between the first and last parts of the following passage will be apparent to all. "At the head of the French natural philosophy stands Jean Lamarck, who, in the history of the

doctrine of descent, next to Darwin *and Goethe*, occupies the first place. To him will remain the immortal glory of having for the first time brought forward the theory of descent as an independent scientific | theory and established it as the natural philosophical foundation of all biology." He certainly ascribes to Goethe no such "immortal glory" as this. 274

There is but one distinct element in Darwinism that is not also found in Lamarckism. This is the important recognition of the | law of competition among living organisms as a factor in development; that principle [13] which Darwin so forcibly expresses by the phrase "struggle for existence." Lamarck does indeed recognize this "struggle" and the influence it exerts in preventing the unchecked multiplication of any one species from rendering the globe uninhabitable to others. But he seems to regard this as a wise precaution and calculated "to preserve all in the established order." In other words, he recognizes it as a *statical* but not as a *dynamical* law. He fails to perceive its influence in transforming species.

It is the full appreciation of this element that constitutes the real strength of Darwinism; it is the key-stone of the arch of the descent theory, for the discovery and successful illustration of which too great praise cannot be awarded to the English naturalist. But every other important principle embraced in his *Origin of Species* was also contained in more or less definite form in the *Philosophie Zoologique.*

The failure of Lamarck's views to gain the ascendancy so rapidly attained by those of Darwin, was due to a variety of causes. First among these was the general fact that the state of science and public opinion had not, at his time, sufficiently advanced for the general reception of that class of ideas; and any estimate of Lamarck's works which leaves out their silent, leavening influence upon certain classes directly, and thence indirectly upon society at large, is too hastily made and fails to do them justice. Next in importance, in preventing the early spread of Lamarckism, comes

the unfortunate omission, above alluded to, to grasp the great law of biological competition in its dynamic form. As a third influence may be ranked the somewhat direct and undiplomatic method of Lamarck, which never consulted the policy of what he wished to say or courted the approval of high authorities. Every truth in his possession was put forward in the most direct and naked manner, regardless of the shock it might produce upon a world still groping in the murky atmosphere of teleology. Still a fourth element of weakness in the Lamarckian philosophy was the inadequate emphasis which he laid upon the most
275 important of all his principles, that of | heredity, and the correspondingly undue importance ascribed to habit, to use and disuse, as a direct agent in the modification of organs. The real failure here was to grasp the true connection and coöperation of these two prin-
[14] ciples. In short he seemed but dimly | to perceive the manner in which the inheritance of slight variations, however produced, and their transmission to successive generations, brings about, in the course of time, the transformation of some, and the extinction of other species. It is the clear conception and forcible presentation of this principle and its happy combination with that of the perpetual competition going on in nature, that gives to Darwin's exposition that air of extreme probability and that power of universal conviction so characteristic of his works. The importance of this distinction between the methods of the two naturalists in expressing this conception may justify me in borrowing a few very appropriate terms from the *Biology* of Herbert Spencer for its better illustration. We may then say that while Lamarck seemed clearly to comprehend the influence of the *environment* (*milieu*) upon the *organism*, and to attribute the results to this as the one great and sufficient cause, he failed on the one hand to take in the full scope of the environment, and on the other to conceive of all the susceptibilities of the organism. In his conception of the former he inade-

quately, if at all, appreciated the organic element, the influence of one organism upon another objectively considered as a modifying force. In his notion of the organism and its susceptibilities he laid too great stress upon the principle of "*direct equilibration*," and comparatively little upon the far more important one of "*indirect equilibration*." To the readers of the *Philosophie Zoologique* it seemed a crude, to many a ridiculous, explanation of the length of the fore-limbs and neck of the giraffe, that they had become elongated by perpetual attempts to reach the branches of trees that lay beyond the reach of other animals; and while he admits that this could not have been accomplished by the efforts of any single individual, and ascribes it to a series of cumulative efforts through many generations, thus clearly recognising and expressly affirming the influence of heredity, he yet fails to show the way in which this influence must have been exerted, its *modus operandi*. He does not say, for example, that the great elongation referred to was initiated in some remote ancestor by some slight variation in this direction, either accidental or perhaps due to the animal's efforts; that this variation, proving ad | vantageous and being transmitted to a numerous progeny, 276
rendered their chances of survival in critical periods greater than those of such as possessed no such peculiarity; that this power of survival, | due to this inheritable peculiarity, became thus a constant force which, through [15]
the interbreeding of those possessing it, tended to increase this variation, until in the course of generations it resulted in differentiating the giraffe in the special attributes of length of cervical vertebræ and of anterior limbs, and in giving it its present anomalous position among antelopes. Instead of this, Lamarck says: "With reference to habits it is curious to observe their results in the peculiar form and figure of the giraffe (*camelo-pardalis*). It is known that this animal, the tallest of the mammals, inhabits the interior of Africa, and that it lives in places where the earth, almost always arid and without herbage, compels it to browse

upon the leaves of trees and to be continually exerting itself to reach them. From this habit, long maintained in all the individuals of its race, it *has resulted* that its fore-limbs have become longer than its hind ones, and that its neck has become so much elongated that the giraffe, without rearing upon its hind feet elevates its head and reaches to the height of six mètres (nearly twenty feet)."[4] It will be observed how in this reasoning (and it is so throughout), Lamarck passes from the observed fact directly to the original cause, leaving out the intermediate steps which it is necessary to supply in order to conceive of the manner in which the results are produced. Now, it is precisely this part of the argument that mankind in general require before they are willing to give in their adhesion to a theory. They say: "It all looks plausible enough, but you fail to show us *how* it actually takes place." As in his illustrations, so in his general "laws," Lamarck fails to grasp the principle of Natural Selection. His first great law is expressed in these words: "In every animal which has not passed the limit of its developments, the frequent and sustained use of any organ little by little strengthens, develops, and enlarges this organ, and gives it a power proportionate to the duration of this exercise; while the constant failure to use such organ insensibly enfeebles and deteriorates it, and progressively diminishes its capacities, causing it finally to disappear."[5] His second law is as follows: "All that nature has caused individuals to acquire or lose

277 through | the influence of the circumstances to which
[16] their race has been long exposed, and consequently through the influence of the | predominant exercise of any organ, or through that of a constant failure to exercise any part, it preserves through inheritance (*génération*) in the new individuals that proceed from them, provided the changes acquired be common to both

276 [4] Phil. Zoo., Tome 1, p. 254. Paris, 1873.
[5] Loc. cit., p. 235.

sexes, or to those which have produced these new individuals."[6]

Whatever may be lacking in these two laws, there is certainly contained in them a clear expression of the two prime factors of the theory of descent: viz., heredity and variation; or, as Darwin frequently expresses it, "descent with modification." The elements of availability alone are wanting; those working principles by which the theory was to be erected into a perfect system and its machinery set into running order.

A grand stride had been made, the doctrine of fixity of species had received a fatal thrust, the special creation hypothesis was undermined, teleology thenceforth was in organic nature doomed.

A fifth and last element of weakness in the Lamarckian philosophy may be enumerated, one which Haeckel justly sets down to the greater credit of the illustrious author as indicating how far he had outstripped the intellectual progress of his age, so that it was practically impossible that his views should have been accepted in his own day. This consisted in the acceptance and express enunciation of two doctrines which are still to-day deeply involved in controversy, even among the most advanced scientific men of our times; that of *spontaneous generation* and that of the *simian ancestry of the human race*, embracing in the latter the extreme theory of the development of the mind *pari passu* with that of the nervous system and the brain, and carrying it out to the logical consequence of denying the freedom of the will, in the current sense of the phrase. These were clearly, in Lamarck's day, shocking and atrocious doctrines, and it is doubtless to these chiefly that is to be attributed the neglect of his great contemporary, Cuvier, to give the *Philosophie Zoologique* as much as a passing notice in his report on the progress of natural science; as well as the rebuke of his philosophical views which he saw fit to introduce into his "éloge" (?) of the great scientific

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[6] Loc. cit.

labors of Lamarck. He little dreamed that when these utterances should have been forgotten, and the works of Cuvier consigned to the musty shelves of antiquarian libraries, | the humble effort which he had first disdained to notice and after | wards noticed with a reproach, would emerge from its long obscurity, and, in new and modern dress, find its way to thousands of book tables, as the classic foundation of a great progressive philosophy.

278 [17]

With regard to Lamarck's views on the subject of spontaneous generation, it is due to him to say that he did not espouse any of the crude conceptions which had been maintained on the authority of Aristotle among the scholastic metaphysicians. He repeatedly asserts that it is only the most imperfectly organized beings that could be directly produced by the forces of inorganic nature, and while he could have had but a faint idea of the extreme imperfection of these lowliest creatures, still as only the *least* perfectly organized could, according to him, become the products of spontaneous generation, his careful language on this point completely exempts him from the charge of entertaining gross notions about the origin of life. Haeckel, with his intimate acquaintance with the lowest known forms of organic existence, his *monera*, does not hesitate to declare the necessity of a transition, at some period, from the inorganic to the organic condition; nay, more, he believes that these *monera* are directly evolved, by the mechanical agencies of nature, out of inorganic carbon compounds, and that protoplasm, of which alone these creatures consist, is the initial stage of organic life. With Lamarck, as with Haeckel, it is the logical necessity, rather than any empirical discovery, that renders this doctrine indispensable as a starting point and first link in the chain of organic development. As the latter justly remarks, unless we do this the natural explanation is given up, and there remains no alternative but to fall back upon the supernatural. Herbert Spencer, too, independently of his theory of physiological

units, has felt the force of this *a priori* argument, and has ranged himself on the side of complete consistency. Neither need the teleologists exult at the apparent overthrow, just now so imminent, of the results of Bastian's experiments. From such a result we shall only the better learn *how* nature works, and no adherent of the doctrine of *archigonia* will the less maintain that life must have had a beginning upon the planet. Lamarck leans to the assumption of a perpetual series of such beginnings which are still going on in the present as in the past, a constant play of the originating force. Haeckel admits as much for protoplasm and for his *monera;* beyond this he says it does not concern the theory of descent to go. Darwin, with his character | istic diplomacy, never lifts the dark curtain that hangs between the organic and the inorganic world. 279 [18]

Professor Haeckel is not only an original investigator, but also an original thinker. Primarily a specialist and investigator of the minute histology of living organisms, there is combined in his mental constitution, along with this indispensable talent, a large development of causality which renders it impossible for him to stop with the mere elaboration of details and the simple accumulation of facts. To him every fact is one of the terms of a proposition, and every collection of related facts becomes an argument, while the sum total of his knowledge of those minute creatures which he has made a life study constitutes in his mind a philosophy. He is at once an investigator and a philosopher. To the former quality his numerous monographs of the lower invertebrates sufficiently testify. His monographs of the *Radiolaria* (with an atlas of thirty-five copper plates), of the *Geryonidae*, of the *Siphonopora*, but especially of the calcareous sponges, belong to the minutest and most exhaustive histological researches of modern zoölogy. In all these, but particularly in the last named, the author has constantly before him a theorem to demonstrate. He expressly avows that his investigations into the calcareous sponges were undertaken with a view to an analytical

solution of the problem of the origin of species. He seems not to have feared thus to invite the charge of having resolved, in this investigation, to verify the argument of Darwin, the perusal of whose great work had induced him to undertake it. Nor does he fail to prove all he hoped to do. On the contrary, he claims to have overwhelmingly established all the principal claims of his English contemporary. The objection had been raised that the Darwinian theory did not rest upon a sufficient body of observed facts; that it was a mere plausible synthesis from a too meagre analysis. Haeckel holds up his two volumes, containing the results of his five years of indefatigable labor on these lower organisms, and his atlas with its sixty carefully drawn plates, all elaborated from the most abundant materials from all parts of the world, and challenges the scrutiny of his scientific opponents. The doctrine of the fixity and invariability of species, already reeling under the blows of Lamarck and Darwin, he claims, is therein completely demolished. He proves that in this group of animals
280 the number of genera and species depends altogether
[19] upon the | meaning which each naturalist may happen to attach to these terms. He may class them all under one genus with three species, or under three genera with twenty-one species, or under twenty-one genera with 111 species, or under thirty-nine genera with 289 species, or even under 113 genera with 591 species, according as his conception of genera and species be wide or narrow. In fact, the 591 different forms may be so arranged in a genealogical tree that the ancestry of the entire group can be traced back to one common form from which all the rest must have descended, undergoing the modifications induced by the varying conditions of their existence. This common ancestor Haeckel believes to be the *Olynthus*.

Thus, the long respected and miraculously created *bona species* is histologically demonstrated a myth.

Rising from the special towards the general, the *Generelle Morphologie* may be next named. It was the first system-

atic attempt to establish the theory of development from the organized facts of comparative anatomy. But the most popular, in its subject matter and style, of the works of Professor Haeckel is his *Natürliche Schöpfungsgeschichte*, consisting of a course of lectures upon the questions in general opened by the *Origin of Species*, but containing the advanced views of the author, already referred to. This work is, therefore, of the highest interest to the general public, and cannot be too strongly recommended. It is divided into five parts designated by the author with the following titles, respectively, each of which sufficiently characterizes its contents: 1, Historical Part; 2, Darwinistic Part; 3, Cosmogenetic Part; 4, Phylogenetic Part; and 5, Anthropogenetic Part.

His *Anthropogeny* or *History of the Development of Man*, to which we will now confine our attention more closely, is simply an enlargement and expansion of the last part of the *History of Creation*. The greatness of the theme required this, and no one who carefully follows the author through this work will complain that justice has not been done the subject. As may well be imagined, this work covers the most interesting field of investigation and introduces the reader into the most mysterious penetralia of nature. The charm of its diction, the fullness of its illustrations, and above all the perpetual wonderland through which it leads, entitle it to take rank at once among the most instructive and the most fascinating works to which modern science has ever yet given birth. | "The proper study of mankind is man." And yet how tame | appear the most mysterious facts of human anatomy and physiology, as taught to the mass of mankind, compared with the astonishing revelations of comparative embryology and comparative anatomy! [20] 281

As already remarked, Haeckel is a philosopher as well as an investigator. No German philosopher can be without his terminology. Haeckel has his, and it remains to the future to decide whether the ends of science are to be fur-

thered by its introduction. It is at least certain that to understand Haeckel one must understand his terminology. Being much of it of Greek derivation, it undergoes little change by transfer to the English language. In so far, however, as it is German, this difficulty is great, often, indeed, quite insuperable. Everybody admits the inadequacy of some parts of Darwin's terminology. The best English expounders of his theory have found themselves compelled to adopt other terms to convey his ideas with the requisite clearness and force. I have already referred to important improvements introduced by Herbert Spencer before it was possible for him properly to arrange the new biological laws under his universal system of cosmical principles. That author has also, in addition to those before referred to, proposed an excellent synonym for Darwin's most important term, "Natural Selection." This he calls "Survival of the Fittest," which, while it can never of course supersede the former, must be admitted by all to bring to the mind far more directly the idea which it is desired to convey.

Haeckel has felt the need of some adequate terms to characterize the two great classes or types of mind, which not only now, but in all ages, have existed in a state of opposition or rivalry in the world. No matter what questions might arise for solution bearing upon the knowledge or progress of the race, there has always existed this sharply defined opposition growing out of these two constitutionally opposite mental types. Various popular appellations have been employed from time to time, differing in different countries and for different forms of agitation. None of these, however, have struck at the true psychological root of the phenomenon, and the world has been long waiting for a thorough analysis of this subject and the suggestion of a scientific terminology, based upon this groundlaw of the constitutional polarity of the human intellect.

[21] 282 | That Haeckel has fully supplied this want I would not venture | to affirm, but that he has made an important contribution towards such a consummation

cannot be questioned. "If," says he, "you place all the forms of cosmological conception of the various peoples and times into comparative juxtaposition, you can finally bring them all into two squarely opposing groups: a *causal* or *mechanical*, and a *teleological* or *vitalistic* group."

The first of these groups, by requiring every phenomenon to be conceived as the mechanical effect of an antecedent true cause (*causa efficiens*), necessarily erects a cosmogony that is bound together throughout by an unbroken chain of mechanically dependent phenomena. Such a universe is a unit, and throughout its domain there can pervade but one universal law. This all-pervading homogeneous law is the *monistic* principle or force, while the whole theory which thus conceives of the universe is termed by Haeckel, indifferently, the *monistic*, and the *mechanical* theory of the universe. Only those minds that are imbued with this conception as a fundamental quality of their cerebral constitution are capable of appreciating, or of subscribing to the Darwinian and Lamarckian philosophy, which is simply the monistic principle applied to biology. This class has formed in all ages and countries the progressive and reformatory element of mankind.

The teleological or vitalistic group, on the other hand, conceive of all phenomena as produced by a power either outside of nature and acting upon it, or consisting of Nature regarded as a conscious intelligence, and which, in either case, directs everything for an ordained purpose or end (*causa finalis*). This recognition of a cause independent of phenomena renders the operations of nature *dual*, and is designated by Haeckel as the *dualistic* conception, and the body of such conceptions as the *dualistic* philosophy. All teleological conceptions are, of necessity, dualistic, just as all causal conceptions are necessarily monistic. The distinction between teleological and theological conceptions vanishes as soon as we class the pantheists among theologists. This class is the great conservative element of mankind, who, looking upon nature as under the control of Om-

nipotence logically resign all effort either to do or to know into its hands.

Haeckel also employs the term *dysteleology*, in antithesis to teleology, and frequently uses it as a general term to designate the monistic or mechanical philosophy.

283 [22] | The entire body of principles embraced in the Lamarckian, Darwinian, and Haeckelian philosophy, when regarded as having passed through its hypothetical and theoretical stages, takes the form of a science, and receives the very appropriate name, *History of Development* (*Entwickelungsgeschichte*), a term adopted by Von Baer and applied to embryonic development, but extended by Haeckel to embrace also the secular development of specific forms. This twofold application of the term History of Development, suggests the natural division of the science into its two great departments. The first of these is essentially that of Von Baer, and treats of the progress of the individual organism from the earliest embryonic condition throughout the numerous successive stages and transformations through which it passes until it arrives at the perfect state. Properly it does not stop at birth, but continues through life, during which, in many creatures, very important metamorphoses take place. This division of the History of Development is denominated *Ontogeny*. The other grand division, which treats of the development of present living forms out of antecedent forms through the influences of heredity (*Vererbung*) and adaptation (*Anpassung*), is termed *Phylogeny*, a term derived from the Greek word φῦλον, a race.

It is to this latter branch of the History of Development that the attention of progressive minds has been heretofore almost exclusively directed, and the arguments of Lamarck and Darwin have been chiefly drawn from considerations of comparative anatomy, of geographical distribution, and of paleontology. The powerful reënforcement which it has now received from ontogeny was quite unexpected, and the astonishing uniformity with which the ontogenetic facts

support, confirm, and corroborate the phylogenetic arguments, may be regarded as having placed the doctrine of development beyond the stage of theory and speculation, and established it as the first law of Biology.

Although the chief facts of ontogeny had been discovered and recorded by Von Baer and others a quarter of a century before, it was left for Haeckel to first perceive and announce their relation to the law of phylogenetic development, and to urge their irresistible force as arguments for the theory of descent. Von Baer himself, although he had erected them into a "History of Development," seems but dimly to have realized the significance of these embry | onic [23]
metamorphoses which he has observed and described, 284
and as | recently as the date of the late Professor Agassiz's public lectures, is quoted by him in a private letter as still adhering to his doctrine of types, and protesting against that of descent from the apes.[7]

Anthropogeny, or the Genesis of Man, considers all the arguments, both from ontogeny and from phylogeny, in support of the assumption of the descent of the human race in a direct line from the lower animals, shows throughout the length of this line what creatures now existing upon the globe or found fossil in the rocks, stand nearest to this line of descent, and aims to trace the pedigree of the being who is the present undisputed lord of the planet back to the lowest amoeba, and even to the moner. Haeckel does not stop with the ape, with the amphioxus, or even with the ascidian. Guided by the Ariadnean clew of *ontogenesis*, he pursues man's genealogy back through the labyrinth of primordial forms into the cell, and thence still back until he loses it in protoplasm.

Standing, as man does, at the head of the animal kingdom, and forming the last and highest stage of development upon the globe, the history of his progress from the lowest form

[7] Since the above was written, the death of Von Baer has been announced. His last effort was in the nature of a systematic attack on Darwinism.

of organic existence must be coextensive with that of all other beings. It differs, however, from the history of development in general, in not being concerned with any of the branches that diverge at various points from the main anthropogenetic stem. This becomes obvious when we commence to study phylogeny, but may be noted here as a means of better appreciating the true scope of Anthropogeny. A few illustrations will make it clear.

Not to speak of the entire vegetable kingdom which is lopped off at the first stroke, we find, as we ascend the scale, that one after another the great branches of the Zoöphytes, of the Annelids (including all the Articulates and the Echinoderms), of the Mollusca, of the Fishes, of the Reptiles, of the Ungulata and Cetacea, of the Carnivora and Rodentia, and of many other less important groups, are successively passed by and left behind; thus obviating the necessity of following out the special genealogy and development of each of these complicated divisions of natural history. The history of development of man pushes right on, taking such notice only of divergent trunks as is necessary to fix with certainty the position of his line of march.

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[24] II

ONTOGENESIS

THE primary law of ontogenesis, and that which connects it with the modern theory of development, is founded on the discovery of Von Baer, that the different successive stages of the embryonic development of the higher animals bear a singularly close resemblance to certain lower animals in their adult state, and that the embryos of many animals, and of man himself, in their earlier stages, are scarcely distinguishable from one another. This fact, as already remarked, was carefully studied by Von Baer, and the successive stages of embryonic life systematically compared and coördinated. In his great work on the

History of Development of Animals (1828–1837), that distinguished embryologist has given to the world the results of his exhaustive investigations. In this work he announces that the theory of types founded by Cuvier in 1816, upon the facts of comparative anatomy, is confirmed by those of embryology, and shows that the process of development, which is the same for all the animals of any of the four types, is different for those of different types.

Haeckel does not gainsay the general truth of this statement, but simply shows that it cannot be used as an argument against the theory of descent, as Von Baer's investigations were confined to fully differentiated animals of each type, and not extended to the then little known Amphioxus and Ascidians, which later researches have shown to constitute transition forms uniting two types. Besides, as we shall see, however different the course of development of different animals may be, the embryos of animals of higher types pass through phases identical with the adult forms of some of the lower types, though not of others, showing that the four types of Cuvier and Von Baer—Radiates, Articulates, Mollusks and Vertebrates—can neither be regarded as coördinate, nor as regularly subordinated to each other. And this is not all: Von Baer's own facts, and those of many embryologists, show that there must be another type added to these four; viz., the *Protozoa*, and that from this the course of both phylogenetic and ontogenetic development has been through the Worms directly to the Vertebrates, leav | ing the remaining types untouched. It seems, therefore, simply | that the different branches of the main stem have in our time spread so widely, and become so far differentiated by adaptive influences, that even their embryos have lost many of the original traces of relationship. The important fact remains that within the vertebrate type, as within other types, the embryonic stages correspond with wonderful accuracy to the successively ascending classes and orders established for that type.

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[25]

The law of Von Baer, expressed in the most general terms, as laid down by himself, is in these words: "The development of an individual of a definite animal form is determined by two relations: first, by a progressive development of the animal body through increasing histological and morphological differentiation (*Sonderung*); secondly, through simultaneous progressive development from a more general form of the type to a more special. The degree of development of the animal body consists in a greater or less amount of heterogeneity of the elementary parts and of the individual components of a composite apparatus; in a word, in the greater histological and morphological differentiation. The type, on the contrary, is the fundamental relation of the organic elements and organs."

Upon this important law Haeckel puts the new interpretation that the "type" of Von Baer is the representative of the law of *heredity* of Darwin (the *vis centripeta* of Goethe), while the "degree of development" means neither more nor less than his law of *adaptation* (Goethe's *vis centrifuga*).

The parallelism which is found to exist between the facts of ontogenesis and the facts of phylogenesis, between the embryonic forms of higher, and the adult forms of lower organisms, is one of the most astonishing discoveries which science has ever made. It is one which would have been least likely ever to be reached by conjecture or by any form of *a priori* reasoning. There was but one possible mode of reaching this truth, and this was by long and patient investigation of the minutest objects and most occult phenomena, without the aid even of a "working hypothesis."

Such a truth must have a meaning. This meaning Von Baer himself never realized, and when pointed out to him by others, never accepted. Yet I venture to predict that no unbiased reader of Haeckel's *Anthropogenie* will any longer doubt the justice of his | conclusions respecting the significance of this marvellous coincidence. The believers in miracles, who refuse to accept this explanation, will have discovered the most miraculous

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of all miracles. The singular alleged action of Providence in stirring fossil shells and bones into the earth, of which the mountains were made, "as a cook stirs raisins into a pudding," would be an intelligible phenomenon compared with this. That a man should begin his existence as an *amoeba*, should subsequently turn into a *worm*, a little later should become a *lamprey*, later still a fish, and after passing through amphibian, reptilian, monotreme, marsupial, lemurian, and simian forms, should at last emerge with the human shape—this series of remarkable metamorphoses, if required to be explained on the assumption that it is directed by the arbitrary will of the Creator, would furnish a more fatal stumbling-block than even the presence of those useless and usually deleterious rudimentary organs, which all higher animals are found to possess. For even if we can bring ourselves to comprehend how the Creator may, for some inscrutable reason, introduce many arbitrary irregularities into his handiwork, according as he may be actuated by this or that caprice, we are still at a loss to understand how he should wish to carry on a whole system of freaks in the embryo, which have a manifest correspondence with the mature forms of life known to exist upon the globe, unless there be some causal connection between the two systems. Nothing short of the most complete abnegation of reason, nay, of a strong effort to accept the unreasonable, can prevent the mind, cognizant of these two series of facts, from becoming thoroughly convinced that such a dependence must subsist.

The science which embraces both the ontogenetic and the phylogenetic development of life, the genesis of life in general, is called by Haeckel *Biogenia*, a science, as he remarks, as yet scarcely founded. The law which expresses the relation between the facts of ontogeny and the facts of phylogeny is, therefore, the fundamental law of *biogenia*. Stated in the most direct manner, this law is that "phylogenesis is the *mechanical cause* of ontogenesis." From a somewhat altered point of view, the same idea is con-

veyed by saying that ontogenesis is a *brief recapitulation* of phylogenesis, or, that the history of the *germ* (*Keimesgeschichte*) is an *abridgment* or *epitome* of the history of the *race* (*Stammesgeschichte*). Mathematically enunciated, the germ-development becomes a | *function* of the race-development, so that every differentiation of the latter carries with it a corresponding and consequential differentiation of the former. This is the fundamental law of organic development, the great biogenetic ground-principle, to which the student of the history of development, whether of its ontogenetic or its phylogenetic aspect, must continually recur. The law of heredity which Goethe calls "the stubborn power of permanency in whatever has once possessed reality," while it graciously yields to the influence of surrounding circumstances and admits of progress, nevertheless requires, with all the rigor of sovereignty, that every step forward shall be taken through the established channels, and with due respect for the most ancient forms. The human germ may, indeed, develop and perfect itself in the highest form of organized existence, but the old and time-honored fish-form and worm-form and amoeba-form, nay, even the moner-form, must be respected, and the proud man-germ must humbly bow to the inexorable decree of Nature, and must undergo this manifold and repeated *metempsychosis*, which in its strange reality eclipses all the dreams of Thales and Pythagoras.

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Phylogenesis, which is a cause, begins with the moner; ontogenesis, which is a consequence, begins with the cell. For man, as for all animals that have advanced beyond an extremely low stage of existence, there is but one mode by which new individuals of the race can be created and the race itself perpetuated, and that is by the contact of two germinal principles having opposite sexual polarities. Each of these principles is a simple cell. The male is the sperm-cell, the female the germ-cell. Only by the union and literal blending of these two cells can generation take place.

The cell is the lowest organized form of existence. It is also the last term in the histological analysis of the tissues of the body. An animal is ultimately nothing more than an organized assemblage of cells, a compound individual.

The moner is a lower form of existence than the cell, the lowest known form, and may be distinguished as a wholly unorganized and undifferentiated individual.

There are but two essential properties of a cell, a central *nucleus* and surrounding *protoplasm*. The only organization, the only differentiation, is that which distinguishes these two substances. And | this is itself very slight. [28]
Chemically, they can scarcely be distinguished. Both
consist of a carbon compound containing a | certain 352
proportion of nitrogen, and belong to the albuminous group, of which all animal tissues are principally composed. The nucleus is generally of a darker color, but sometimes of a lighter, and may or may not contain in its centre a minute dot—*nucleolus*. It also may or may not be surrounded by a membranous envelope. This is generally present in the cells of plants, while it is generally absent in those of animals.

The form of cells differs according to the circumstances of their existence. They are the most plastic and easily modified by external conditions of all organized beings, and therefore make the best subjects for the study of the law of adaptation. Stationary cells in a motionless medium are uniformly spherical. When subjected to pressure they assume hexagonal, elongated, or compressed forms, according to the nature of the pressure. Cells that are active in a liquid medium have a portion of the matter composing their outer parts extended into a caudal appendage away from the direction of motion. In addition to the forms named, cells frequently assume others, sometimes taking wholly amorphous shapes, resulting from the particular conditions to which they may be subjected. They frequently change their form, and this not only from external influences, but in obedience to internal or subjective de-

terminations. For a cell is a living creature. It possesses all the essential characteristics of an organized individual. The only functions necessary to characterize a living being are nutrition and propagation. Both these the cell possesses. It grows by the absorption of nourishment from the medium in which it lives. Where this nourishment is not uniformly mingled throughout the medium, but exists in the form of scattered solid particles, the cell acquires the power to extend portions of its substance into temporary organs of grasping (*pseudopodia*), and thus to enclose and devour its food. It thus improvises a mouth and jaws on whichever side it may need them, and feeds itself after the manner of another animal.

The cell propagates, like many much higher organisms, by division, or fission. It continues to take nourishment and to grow until it reaches the limit fixed by heredity for its size, and then, instead of growing larger or of ceasing to take food, it divides into | two distinct cells. Each [29] of these then goes through with the same process of nutrition and division, and so on.

But besides these two essential phenomena, which are common to all life, whether animal or vegetable, the cell performs two other | truly animal functions. It pos- 353 sesses the power of *locomotion*, and the faculty of *sensation*. Cells with caudal appendages, called lash-cells (*Geisselzellen*), have acquired that form in consequence of their independent activities in their liquid medium. Various other forms are traceable to similar causes. As a proof of the possession by cells of a faculty of sensation, we have only to consider the efforts of various kinds to obtain their food. Some are actually carnivorous, and show a certain degree of dexterity in capturing their prey. They are, therefore, not only capable of feeling, but, in a qualified sense, of thinking and of reasoning.

There is no essential difference between the sperm-cells and germ-cells of higher animals, and the simple cells of which many lower animals consist, and beyond which they never

advance. We can only say that among the infinitely varied forms of life, we find that, while most creatures have developed into highly compound states, and only revert to the original unicellular condition at the beginning of each individual's existence, there are still many creatures that never progress beyond this primordial stage, and whose entire existence is passed in the form and condition of simple cells.[8] Among such creatures may be named the *Amoebae*, the *Gregarinae*, the *Infusoria*, etc. These animals, as well as those which consist simply of an accumulation or aggregation of cells, such as the *Labyrinthuleae*, etc., and which form the second stage of development, never rising above the cellular condition, are classed by Haeckel, together with his *Planaeada*, in a grand division or department by themselves, and called *Protozoa*. A further ground for this classification will be seen later.

According to the fundamental biogenetic law above stated, the cell must be the primordial form out of which all more highly organized beings, including man, have developed, since it is the original stage of their ontogenetic development. And as there still exist unicellular beings resembling the sperm-cells and the | germ-cells of [30] higher organisms, the deduction is warranted that all higher creatures are the descendants of some form of these unicellular beings. Considering the differences that may and do exist even in cells, and in animals consisting of a single cell, Haeckel is led to the conclusion that of all the unicellular creatures known to science, the *Amoeba* bears the strongest evidence of being the original progenitor of the human race.

The history of the discovery of the human *ova* and *spermatozoa* | deserves a brief notice. In 1672, De Graaf 354 discovered the Graafian vesicle, which he supposed

[8] A complete description, both popular and systematic, of all the unicellular organisms known to exist, was published by Prof. Haeckel in 1878, entitled: *Das Protistenreich*, of which he has kindly sent the writer a copy.

to be the ovum itself. In 1797, Cruikshank, Prevost, and Dumas found and described the true ovules, but failed to comprehend their real nature and importance. It was left for Von Baer, thirty years later, to complete the discovery, and place it before the world in its full light. Pürkinje (1825) and Wagner (1835) added important contributions in the discovery of the germinative vesicle or nucleus, and the germinative dot or *nucleolus*. The fact that the ova are simple cells could not be recognized until after the founding of the universal cell-theory by Schleiden (1838) and Schwann (1839). It was then perceived that eggs themselves are cells, differing in scarcely any respect from the cells of other tissues.

The discovery of the spermatozoa, or male seminal animalcules, was first made by Leeuwenhoek in 1674, and confirmed by Louis Ham in 1677. A long war arose between the so-called *Animalculists* and *Ovulists*, the first of whom believed that the animalcules were the true and only germs of the future being, which simply found in the ova a suitable *matrix* for their development, while the latter maintained that the ova were the true germs, which were only affected with a germinative impulse by contact with the spermatozoa. The real nature of this mysterious process has only been clearly brought to light by the labors of more modern investigators, among the foremost of whom must be ranked Prof. Ernst Haeckel, of Jena.

The ova of all mammals are identical in all essential characteristics. They all possess both nucleus and nucleolus, are of a spherical form, and about one-tenth of a line in diameter, and all acquire at maturity a membranous envelope called the *chorion* or *zona pellucida*. The egg of a mouse and that of an elephant cannot be distinguished from each other or from the human ovum in any respect. They are all simple cells.

[31] | The sperm-cells of mammals possess a no less marked similarity. They are exceedingly small as compared with the germ-cells, and possess long filiform

caudal appendages. The *chorion* is wanting. Their form may be divided into head, body, and tail, but between no two of these parts can there be said to exist any clear line of separation. The head contains the nucleus surrounded by protoplasm or cell-substance, which is carried backward in gradually diminished quantity, forming the remaining portions. It was not | until the year 1873 that it was discovered that these important organisms, 355 like the female ova, were simple cells. This discovery is in great part due to Prof. Haeckel's own investigations.

We may now consider the immediate consequences of the union of the sperm-cell with the germ-cell. The *spermatozoon* penetrates the many times larger *ovum*, making its entrance through minute pores in the *chorion*, and mingling at once with the germinative matter of the cell. A remarkable change takes place. Two perfect cells with opposite sexual polarities have been drawn together by their inherent affinities. They have met and their substances have commingled. They literally blend into one individual. But that individual is no longer a cell. The sperm-cell has lost its individuality and wholly disappeared. The nucleus of the germ-cell has likewise entirely vanished. The entire interior of the original cell has become a homogeneous mass of protoplasm, no longer possessing any traces of organization. Only the *chorion* remains to determine its original form. It is a case of retrogression (*Rückbildung*), of reversion to the lowest type of existence. The human being who, as represented in sperm-cell and germ-cell, stands on the plane of the *amoeba* and the *infusorium*, has gone back, on the union of these cells, to that of the *moner*. As if nature was not satisfied that any form of life should begin with the cell, the second stage of existence, but required absolutely that every being, no matter how high might be its destiny, should go to the very foot of the scale and climb the entire distance, in order that it might pass through every form that has belonged to its whole line of ancestors.

From another point of view, this union and literal blending of the male and female principles is not only of the highest intellectual interest, but is calculated to awaken the most lively æsthetic sentiments. Nothing more poetic
[32] or romantic has ever been presented | to the human fancy by all the fictions of the world than the marvellous reality of this courtship of cells! The very fountain-head of love (*Urquelle der Liebe*) is reached in the affinities of two cells! The ruling passion of all ages has its ultimate basis in this new-found physiological fact. When the march of science shall have exposed the false basis upon which the present artificial code of social life rests, and when the fears of those who can imagine nothing better
356 shall have been dispelled, then let the future Homer of science sing, not the illicit loves of Paris and | Helen, which whelm great nations in untimely ruin, but the lawful wooings and the heroic sacrifices of the sperm-cell and the germ-cell as they rush into that embrace which annihilates both that a great and advancing race may not perish from the earth! And here there is no fiction, there is not even speculation. Both the plot and details of this tale belong to the domain of established fact, and rest upon the most thorough scientific investigation.

The structureless form first assumed by the fecundated ovum is termed a *cytod*, but from the circumstance of its being the ontogenetic form, which corresponds to the moner, Haeckel has also applied to it the systematic name of *Monerula*. In his system this is the stage of germ-development which the moner, before its further differentiation, had impressed upon all organic matter, and through which all higher forms must consequently invariably pass.

This *cytod* or *monerula* stage is, however, of short duration. Very soon the homogeneous mass acquires a new nucleus, and thus again assumes the character of a simple cell. This second cell-form is so similar to that of the unfecundated ovum that many observers who had actually witnessed the cytod-form, on looking again, soon after, and seeing only

the primary cell-form, had discredited their intermediate observations. It was not until the entire transformation had been repeatedly witnessed through all the steps of its progress, that the fact of such a strange transition became established beyond a doubt.

The new cell, although indistinguishable from the old, possesses an invisible element derived from the absorbed substance of the sperm-cell, which gives it the potential character of the parents. The old cell, as such, was an independent living organism, capable of performing the essential functions of life, including that of | reproducing its kind; *i. e.*, of dividing up into cells like itself, but which could progress no farther. The new cell, on the other hand, is the germ of a highly-organized being. [33]

This is the *second*, or *ovulum-stage* of development which has been impressed upon the germ by the *amoeba* stage of phylogenetic development. The human being is now an *amoeba*.

The next step in the development of the fecundated germ consists in a process of division which takes place in the nucleus. This first divides into two, and the surrounding protoplasm arranges itself into two hemispheres so as to form a double cell. Then each of these two nuclei, with its surrounding protoplasm, | goes through the same process, dividing the cell into four parts. The same process is then repeated for each of these parts, and so on, increasing the division in a geometrical progression, until the entire contents of the *chorion* consist of a mass of closely-aggregated minute cells. 357

The form which the fecundated egg has now assumed is called, from its resemblance to a mulberry, the *Morula*, and constitutes the *third*, or *Morula-stage* of development. It is merely a compound form of the simple cell. Instead of one comparatively large cell, it now consists of an aggregated society of small cells. Prof. Haeckel has established a theoretical group of compound amoebae, which he calls *Synamoebia*, as the phylogenetic ancestral form to which the

Morula owes its existence; but it has been shown by the researches of Archer and Cienkowski into some species of *Cystophrys* and into the *Labyrinthuleæ*, that these hypothetical *Synamoebia* have an actual representation in the fauna of the globe. These creatures are found to consist of formless accumulations of similar simple cells.

The *fourth* stage of germinal development is the *Blastosphere-stage*. It consists of a transformation of the *Morula*, which is brought about by the absorption of a clear fluid from the medium in which it is situated, which collects at the centre and crowds the cells outward, pressing them together until they are made to form a single layer upon the inner surface of the chorion, and thus leaving the whole interior filled only with the new liquid. The germ is enlarged during the process, from its former diameter of about one-tenth of a line to that of half a line. The cells now forming this single layer have assumed a hexagonal shape, due to their | lateral pressure against one another. The new [34] form is denominated the *Blastosphaera* or *vesicula blastodermica*, while the cellular layer bears the name of *germinal membrane* (*Keimhaut*) or *blastoderm*.

The blastosphere is a stage of embryonic development which is common to all creatures that have a higher organization than that of the synamoebian societies of cells. In many of the lower forms of life it becomes a stage of metamorphosis rather than of embryonic development, since these minute blastospheres lead independent lives for a time, as the larvae of higher forms. This is the case with the calcareous sponges, with many zoöphytes, worms, ascidians, and molluscs. Such larvae are called *Planulae*. They are usually covered with cilia, which serve as aids to locomotion. | These facts alone would justify 358 the believer in the dependence of ontogeny upon phylogeny in maintaining that this stage had once formed the highest plane of development, and that there had once existed a race of creatures which, after passing through the three preceding stages, completed their ca-

reer as true blastospheres, and that all higher organisms must, in that sense, be descendants of such a race. Haeckel assumes such a group of creatures, which he calls the *Planaeada*. This hypothesis, however, was scarcely necessary, from the fact that there are animals well known to science which conform in their general structure entirely to this stage of development. Many such creatures now exist, both in the sea and in fresh water, consisting of a single exterior layer of cells, surrounding a fluid or gelatinous interior, and usually provided, like the larval forms, with locomotive cilia. Especially may be mentioned the *Synura* in the *Volvocinae* and the *Magosphaera planula*. The latter was discovered and named by Haeckel, who has carefully traced its development through the lower stages, and proved the *Planula* to be its highest and mature condition. Such an animal is, therefore, a true *Planaea*, as strictly so as are the members of Haeckel's theoretical ancestral group of *Planaeada*.

To the philosophical embryologist, the blastosphere-stage presents an extraordinary interest. Nothing could illustrate this better than the remarkable utterance which it has elicited from Von Baer himself, one of the few of his statements which possess not only an ontogenetic, but also a phylogenetic significance. "The farther we go back," says he, "the greater agreement do we find, | even [35] in the most different animals. We are thus led to the question, whether at the commencement of development, all animals were not essentially alike, and whether there does not exist for all a common primordial form? As the germ is the undeveloped animal itself, so it may be reasonably stated that the simple blastosphere (*Blasenform*) is the common fundamental form out of which all animals are, not only ideally, but historically developed."

The next and *fifth* stage of embryonic development is the most important of all, as it leads us directly to the consideration of Haeckel's celebrated "*Gastraea Theory*." The ontogenetic form is called the *Gastrula*, which differs in two

important respects from the *Planula*. Instead of a single cellular layer, as in the latter, the Gastrula possesses two such layers, one immediately within | the other.
359 These layers themselves differ from that of the Planula in consisting of several rows of cells instead of one, thus forming two distinct coats composed each of several layers of cells. These two coatings are quite independent of each other, and may be easily separated, which is not the case with the layers of cells composing each coat. The two coats differ still further from each other, in being made up of unlike cells. Those of the inner are larger, softer, and darker-colored than those of the outer.

The other important distinction between the Gastrula and the Planula is the possession by the former of an orifice at one point on its surface, through which it receives its nourishment and excretes refuse materials. This form of the *Gastrula-stage*, however, it should be stated, cannot be identified in the higher vertebrates. In man it is represented merely by a disc-shaped thickening at one spot on the spherical germ, and the formation there of the two primary germinative layers which extend round into a sort of sac, which is the unmistakable homologue of the typical *Gastrula* of the lower animals.

The process by which the embryo passes from the *Planula* to the *Gastrula* state, though simple, would be somewhat tedious, and the reader must be referred for the details of this transition to treatises on embryology, or to Prof. Haeckel's own work.

An extraordinary interest attaches to this stage of ontogenetic development, in consequence of its carrying the embryo across the line which separates the *Protozoa* from the *Metazoa*. Haeckel insists upon this as the primary division of the animal kingdom.

[36] | The *Protozoa* are not a coördinate department or type with the Vertebrates, Mollusks, etc. They constitute a sub-kingdom, coördinate only with the other sub-kingdom of *Metazoa*, under which these types

all fall. To class the *Protozoa* among the Radiates would be equivalent to placing the Cryptogams under the Endogens in a botanical system. The reasons for this are purely ontogenetic. The *Gastrula* possesses the two primary germinative layers, which belong to none of the forms below it. The most thorough embryological research has established beyond a doubt the important fact that all the tissues of the body of every animal that develops beyond that stage are evolved out of the one or the other of these primary layers. The *Protozoa* and the *Metazoa* are therefore separated by the broadest possible line of demarkation, the former possessing no primary germinative layers, while the latter are either composed of them or developed out of them.

| The extreme importance of these cellular layers, therefore, becomes at once apparent, and it is upon 360 the manner in which the different tissues of the body are formed out of this simple building material that the most patient and indefatigable embryologists have been engaged during the past half century. It is found that from the outer layer or *exoderm* are formed: first, the *epidermis* and organs arising from it (hair, nails, feathers, scales, etc.); secondly, the nervous system and the most important part of the organs of sense; thirdly, the greater part of the flesh of the body, the muscles; and fourthly, the skeleton of vertebrates; in short, all the organs of *locomotion* and *sensation*.

Out of the inner layer, or *entoderm*, on the other hand, are developed first, the inner lining or epithelium of the entire cavity of the body, together with that of all the glands and organs belonging to it, lungs, liver, etc.; secondly, the muscles of the internal vegetative system, including the heart; and thirdly, the cells of the generative organs. This last, however, is still open to some doubt.

In consequence of these special functions performed by each of the two primary germinative layers, the outer one has been called the animal germ-layer (*animales Keimblatt*),

and the inner the vegetative germ-layer (*vegetatives Keimblatt*). The Latin terms *exoderma*, *dermophyllum*, *lamina dermalis*, and *lamina serosa*, have also been applied to the former, and *entoderma*, *gastrophyllum*, *lamina gastralis*, and *lamina mucosa* to the latter.

[37] | The *Gastrula* is a common larval form of many lower animals, such as Sponges, Polyps, Corals, Medusae, Worms, Mollusks, and Radiates. It is also a larval form of the two most interesting of all animals for the history of development, viz., the Ascidian and the Amphioxus. Many Zoöphytes and sponges are indeed nothing more in their final state than an aggregation or society of *Gastrulae*. They therefore constitute a compound *Gastraea*.

There is still another larval form belonging to this class which possesses an almost equal interest with the Gastrula. This is the *Ascula*. It belongs to the life histories of both Sponges and Medusae, being developed out of the gastrula-form, and from it the fundamental biogenetic law leads us back to the long extinct *Protascus*, or primordial sac, which was the ancient progenitor of the Zoöphytes. It is fixed to the bottom of the sea, having its open end directed

361 upward. No longer needing the cilia em | ployed by the Gastrula as organs of locomotion, these are consequently wanting. Its body consists of a simple sac or stomach, whose walls are formed by the two primary germinative layers in all their primordial simplicity.

The already famous *Gastraea Theory* of Haeckel is nothing more than the simple application of his fundamental biogenetic law to the Gastrula stage of development. By this law he is led to the conclusion that at one period in the history of the globe, an animal, having at maturity the form and organization of the *Gastrula*, and to which he gives the name of *Gastraea*, constituted the highest form of organic development upon it, and that from this primordial state of the two primary germinative layers the process of differentiation of organs proceeded, until the present complex

state of the animal kingdom has been reached, even as from the embryonic gastrula-form the highest of living beings are now developed through this ontogenetic recapitulation. "The Gastraea," says he, "must have lived at least during the Laurentian period, and sported about in the sea by means of its ciliated exterior coat, in the same manner as the free-moving Gastrulae now do."

The great interest which attaches to the Gastraea Theory, as already remarked, arises out of the immense importance of the primary germ-layers as the basis of all future histological development. That which carries it further out into the field of speculation, however, and thus in one way adds still more to its interest, | is the difficulty both in finding the true homologue in man and the higher [38] vertebrates generally, of the Gastrula of the Ascidian and Amphioxus, and also in finding any good systematic representative of the ancestral Gastraea.

The rest of the history of the ontogenetic development of man is the history of the differentiation of the two primary germinative layers. The Gastrula stage has furnished, in these two layers, the raw material for the entire future structure. By watching the progress of growth in exoderm and entoderm, the successive tissues of every part of the body may be traced to the highest degrees of specialization. From this point of view that stage possesses an interest far exceeding that of all those that have preceded it, for in it is found the first truly specialized organ. That organ is the stomach. The two essential functions of life are nutrition and reproduction. The one is the promoter of ontogenetic, the other of phylogenetic development. But, as we saw in the cell, these two func | tions are 362 originally one, and that one is nutrition. Reproduction appears here as a mere continuation of nutrition. Nutrition goes on to the limit of growth, when division takes place. Nutrition is commuted into reproduction. *Generation is phylogenetic nutrition;* a truth which we should never have reached except by the study of the lowest organ-

isms. Nutrition, therefore, is the one essential function of life. The organ of nutrition is the stomach. How significant, and yet how reasonable, that in the course of development the first specialized organ should be the stomach, and that the first creature possessing a specialized organ should consist wholly of a stomach! Such a form is the *Gastrula;* such a creature was the *Protascus;* and such is the hypothetical *Gastraea* of Haeckel.

The *sixth* stage of the ontogenetic development gives the human embryo the form and organization of a worm. Our moral and religious teachers have from time immemorial delighted in reminding us that we were but "worms of the dust." They should thank science for demonstrating that they were right. We might almost give them credit for an inspirational insight, did they not render their sincerity questionable by the indignation they evince when told that in the same sense that we are worms, we are also apes.

The first important step in the progress of embryonic development, after leaving the Gastrula-stage, is the formation of two | additional germ-layers out of the two original ones. The exact mode of their development is still under discussion among embryologists. Haeckel believes that the original exoderm and entoderm secrete each a new layer of cells from its inner surface; that is, from the surface of each which is contiguous to the other, so that the two new layers lie against each other and separate the primary by the thickness of both. It is, nevertheless, considered that in the process the original constitution and identity of the primary layers are destroyed, so that they have virtually resolved themselves into four secondary germ-layers. The two outer layers, however, now perform together the office of the original exoderm, while the two inner ones take the place of the entoderm. This division into four secondary germinative layers is the final division, all the tissues, without exception, being formed out of these, as they have in nearly every case been traced.

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The names assigned by Von Baer and by Haeckel to these secondary layers have reference to the functions which they are found | to perform. Being all German in their etymology, they are difficult to render into 363
English. The following may answer as such an imperfect version: Numbering them from the outside, the first is called by Von Baer the skin or dermal layer (*Hautschicht*), and by Haeckel the dermo-sensory leaf or fold (*Hautssinnesblatt*). The second is the muscular layer (*Fleischschicht*) of Von Baer, and the dermo-fibrous leaf or fold (*Hautfaserblatt*) of Haeckel. The third is Von Baer's vascular layer (*Gefässschicht*), and Haeckel's gastro-fibrous leaf or fold (*Darmfaserblatt*). The fourth, or extreme inner layer, Von Baer has denominated the mucous layer or membrane (*Schleimschicht*), while Haeckel calls it the gastro-glandular leaf or fold (*Darmdrüsenblatt.*) Space will admit of no further following out of this interesting part of the history of embryonic development.

All worms are composed of these four secondary germ-layers, the lowest possessing them in their greatest simplicity. The popular idea of a worm is an elongated creature, consisting of many joints or rings (*somites*), but this is only a compound state of the primitive worm, each ring or joint constituting, zoölogically, a distinct individual, and possessing morphologically, if not physiologically, all the characters of one. The primitive worm has but one joint. Among the lowest of the worms are the *Turbellaria*, which | in many respects resemble the *Gastrulae* [40]
of some higher animals. Like them, their body consists of a simple sac with only a single orifice, and even possesses the ciliary organs of locomotion. The great difference lies in the nature of the cellular layers composing this sac. In the *Turbellaria* these are the four secondary instead of the two primary germinative layers. Haeckel reasons here to an ancient primordial worm (*Urwurm*, *Prothelmis*), corresponding in all respects with this stage of embryonic development in man and the higher animals

generally, and from which not only all other worms, but all creatures higher than the worms, including mankind, have descended. This worm-stage acquires an increased interest from the circumstance that here the main trunk divides, sending off the articulate branch in one direction and the mollusk branch in another, leaving only the vertebrate stem. The embryo assumes a certain bilateralness, the four secondary germinative layers grow together at their dorsal median line, and a *chorda dorsalis* is formed. This is the true *Chordonium-stage*. The embryo now has the closest affinities with the larval state of the Ascidian,
364 which, strangely enough, though wholly devoid of a *chorda* | in its final state, has a well-defined one in its larval state. There is another creature, the *Appendicularia*, which possesses a *chorda dorsalis* throughout its existence, although in all other respects it is a true worm, and belongs, with the ascidians, to the *Tunicata*. This animal is the true connecting link between the worms and the vertebrates, between the ascidian and the amphioxus. The hypothetical *Chordonium* of Haeckel, the assumed ancestor of the human race at this stage, and exact representative of the embryo at this period of its growth, differs scarcely at all from the *Appendicularia*. It is the common ancestor of the *Tunicata* and the *Vertebrata*.

From a worm, the embryo passes directly into a vertebrate. As the ascidian larvae, the appendicularia, and the amphioxus are separated only by the smallest differences, although the two former are clearly worms, while the latter is clearly a vertebrate, so the corresponding transition stages in the embryo are distinguished only by almost imperceptible shades.

The future man is now a vertebrate, but without distinct vertebrae. He is wholly without brain or cranial enlargement, without a regular heart, without mouth, without
[41] limbs. He now be|longs to a great subtype of the *Vertebrata* which Haeckel denominates the *Acrania*. This entire subtype has now but a single known living

representative on the globe, the amphioxus[9]; but Haeckel believes that a period existed when the *Acrania* greatly prevailed over the *Craniota*, or cranium-bearing vertebrates, and peopled all the seas and waters. This *Acrania* or amphioxus form constitutes the *seventh* stage of ontogenetic development.

The next or *eighth* stage is the *Lamprey* or *Monorrhina stage*. The nervous system and the vertebral column begin to differentiate. The spinal marrow undergoes a slight enlargement at its anterior extremity, which is the rudiment of the brain. The vertebral column begins to develop out of the rudimentary *chorda dorsalis*. This does not take place by a gradual, simultaneous formation of all the vertebrae along the line of the *chorda*, but, singular as it may seem, by the formation of one vertebra after another, beginning with the most anterior. This remarkable | process points unmistakably to the composite character of the frame-work of every vertebrate body. Each vertebra of a vertebrate, like each ring of an annelid, represents a distinct and once independent unit of a compound organism. 365

The present *Cyclostomata* or *Monorrhinae* are believed by Haeckel to be the sparse remains of a once great group of animals, which in ancient times shared the possession of the globe with their gradually increasing rivals, the *Amphirrhinae*, which had sprung from them just as the embryo of every higher vertebrate passes from the condition of the one into that of the other. The type of the former is the still living Lamprey or *Petromyzon*. As the names imply, the *Monorrhinae* have but one orifice for mouth and nose, which is of a circular shape, and is used as a sucker, while the *Amphirrhinae* are provided with a pair of jaws and two

[9] A second acranial animal, discovered near Peale Island, Morton Bay, Australia, has very recently been reported to the Royal Society by Prof. W. Peters, who has described it under the name of *Epigonicthys cultellus*. This discovery is of the highest interest to naturalists. 364

nasal orifices. Excluding the Amphioxus (*Acrania*) the entire vertebrate type (*Craniota*) falls under these two groups, the *Amphirrhinae* embracing all the higher vertebrates, from the lower fishes upward.

From the form of the first of these groups to that of the second the embryo now passes, and enters upon its *ninth* stage of development; it becomes a fish. But as *natura*
[42] *non facit saltum*, this first | fish-form is not that of a true *Teleost*, or ordinary bony fish, but of a *Selachian*. Indeed, the higher fish-form is never attained, but the embryo skims along at the bases of the great ichthyic and amphibian branches, without becoming at any time a true fish or a true Batrachian. This is a very significant fact, and one which, while it is easily accounted for by the general theory of descent, forms at the same time a powerful ontogenetic argument for the truth of that theory. For the typical representatives of any great group exhibit only the extremities of greatly differentiated branches remote from the parent stem, and it is not to be expected that in the corresponding embryonic forms of animals higher up the stem we should see anything but copies of those forms which existed prior to, or at the commencement of, ramification, and which are consequently within the common line of descent of both.

Some will, perhaps, regret that their ancestors should have been worms, while they cannot count in their pedigree either the bee or the ant; others may not feel flattered to be informed of their close relationship with the frog and the toad; but few, I think, will be sorry to learn that their forefathers were not reptiles, though this fact precludes the
366 more pleasant thought of claiming relationship | with the birds; for birds, with all their grace, beauty, and innocence, are neither more nor less than transformed reptiles.

The human embryo passes along the base of the Batrachian branch and through the *Sozura* (thus saving its tail), and so keeps quite aloof from the whole race of lizards,

snakes, turtles, etc., and *a fortiori*, of birds. The unborn man is first a Selachian, then a Lepidosiren, then a Siren, and finally a Triton. His first limbs are fins, his first respiratory organs are gills, and his lungs are at first fish-bladders.

The *tenth* and last stage of ontogenetic progress is denominated by Haeckel the *Amnion-stage*. This stage embraces not only that of all true mammalian forms, but also takes in the two interesting antecedent groups, the *Monotremata* and the *Marsupialia*. Haeckel establishes a hypothetical *Protamnion*, which he locates in the Permian period, and which he claims to have been the original progenitor of all the *Amniota*, or amnion-bearing animals. The distinguishing characteristic of this embryonic form, as the name implies, is the beginning of the development of the important organ known as the *amnion*, which is simply a large extension of the yolk-sac, and is filled with a nourishing fluid. This fluid | is gradually absorbed and appropriated by the embryo, and furnishes a [43] portion of its nutrition. Simultaneously with the amnion is developed also another important organ, the *Allantoïs*, or primordial urinary sac. Both these organs are confined to the three highest classes of Vertebrates (reptiles, birds, and mammals). The embryo now begins to manifest decided mammalian characteristics. Already the gills have disappeared, having become transformed into jaws, hyoid bones, and otolithes; the heart has acquired its four chambers, and the swim-bladders have been specialized into lungs. For a while the uro-genital and excrementary orifices empty into the common *cloaca*, giving it the *monotreme* character. Then, while the allantoïs is still present, a partition separates these, making both open externally. This is the Marsupial stage. Lastly, the allantoïs is transformed into a *placenta*, and the pure mammalian stage is reached. Leaving the great branches of the *Carnivora* and *Rodentia* on the one hand, and of the *Ungulata* and *Cetacea* on the other, the embryo now passes

through the various phases of a Sloth-form, an Ape-form, and an Anthropoid-form; and, conditions being normal, emerges on the two hundred and eightieth day of gestation with the form of a human being.

367 | No one who experiences the least regard for natural truth, whatever views he may hold respecting the meaning of particular facts, can contemplate so remarkable a series of phenomena as this, and realize that he has himself once been the subject of such a strange course of development, without being led into a train of reflection which will open up to his mind broader and juster conceptions of the universe.

At the same time it would be impossible to exaggerate the degree of added strength which a popular acquaintance with the bare facts of ontogenesis would impart to the hypothesis of development or modern doctrine of descent, and thus indirectly to the general conception of the law of universal evolution.

528 [*Third and Concluding Paper.*]

III

PHYLOGENESIS

THE fundamental biogenetic law that ontogenesis is an abridged repetition of phylogenesis, that the transformations through which the individual passes during its ante-natal and post-natal existence in the brief period of its career, are a mere reflection of those

[44] | through which its race has passed during the long ages of its slow development, and that the latter process is the strict physical and mechanical cause of the former—this deepest of all biological laws Haeckel no longer treats as a *theorem* requiring demonstration, but employs it as a *postulate* by the aid of which all the most troublesome gaps left in the anthropogenetic series by the evidences of comparative anatomy, paleontology, and geographical distribution (*chorology*), are satisfactorily closed.

Such gaps have existed along the entire line, rendering it difficult, and in many cases impossible, | to trace it, and leaving so large a part of the whole theory 529
of descent a matter of conjecture, that it was easy for those so disposed to point out unanswerable objections. But once admit the facts of ontogenesis, and miracle alone, and this of the most incredible kind, is the only alternative to the acceptance of the fundamental law, which, candidly viewed in the light of these facts, bears every mark of inherent probability. Not only does this law fill out numerous voids and supply many wholly "missing links" in the phylogenetic chain, but it also confirms, in the most remarkable manner, nearly every item of the evidence furnished by the other sources of proof of the doctrine of descent.

Great, indeed, was the step which this doctrine took when the remarkable revelation was made in the domain of comparative anatomy, that the Amphioxus possessed a *chorda dorsalis*, and that the Ascidian larva contained an even more distinct trace or rudiment of a vertebral column. Professional naturalists without preconceived ideas could no longer resist the inference that here was the true *nexus* between the worms and the vertebrates. Consider now the almost crucial verification which this hypothesis received when it was found that the embryonic stages of every creature higher in the scale of being than the Amphioxus present phases identical with those of that animal and of the Ascidiae, that even the human embryo has its worm-stage immediately succeeded by its Chordonium stage, and this again by its Acranial stage; the collateral proofs extending even to the germinative layers, and thus rendering the correspondence complete and the inference irresistible. Equally pointed illustrations might be drawn from many other points along the line of common descent.

But valuable as is this class of evidence at these comparatively advanced stages, it is still more so far down toward the dawn of | organic existence. For while [45]
in the former it only serves to supply the omis-

sions or verify the testimony of an array of paleontological, anatomical, and chorological facts, in the latter it stands alone as the sole evidence of a tangible character of the development of living forms out of the primordial and unorganized *plasma* of nature, and indeed from inorganic matter itself. These ontogenetic stages have already been considered, and unavoidable mention made of many of the forms to which they correspond, and whose stamp they bear.

The deeper problem of the origin of life on the globe is
530 one | which strictly belongs to phylogeny, and one which Haeckel has not hesitated squarely and boldly to meet. The doctrine of spontaneous generation, or *archigonia*, is by no means so simple as many suppose, and is not to be settled either by the success or failure to originate bacteria, diatoms, and monads, under certain conditions, in organic infusions.

The only form of generation which has ever yet come within the scope of human observation, and which, from the nature of things, can ever be expected to be directly witnessed by human eyes, is, of course, that wherein the offspring proceeds directly from a known and distinct parentage. This form of generation is called *tocogonia*, and genesis itself in its widest sense is, therefore, primarily divided into *archigonia* and *tocogonia*.

The exceedingly complicated subdivision of tocogonia must be passed over, as we need consider here only the simpler but still somewhat complex one of archigonia, or original spontaneous generation. Although nothing is perhaps empirically known respecting this process, its existence as forming the first link in the phylogenetic chain, possesses the highest degree of probability *a priori*, which is not at all lessened by any empirical failures to subject it to the testimony of the senses.

The problem divides itself into two, which Haeckel considers distinct and independent. The phenomenon assumed by the one he calls *plasmogonia*, in which the

genetic process is conceived as taking place in a fluid containing organic matter, which is supposed by some to be essential to the origination of life. The other form of archigonia, on the other hand, conceives the process as taking place in a medium consisting wholly of inorganic elements, and Haeckel accordingly denominates this process *autogonia*, *i. e.*, un|aided self-generation. It will be observed that the great majority of the experiments thus far [46] tried, have been confined to the first of these classes, or plasmogonia. If we now consider the second class, or autogonia, we perceive that this also presents a two-fold problem. It is either a process which, under certain rare and favorable conditions, is going on at all times in some parts of Nature's domains, or it may be one which was only capable of taking place at one period in the geological history of the globe, when conditions existed which were quite different from those now existing, and that all the life now found on the globe has descended through the tocogonic process from the primordial organisms then created.

| To all these questions but one answer can be given; but this is an answer which either must be 531 given, or else the whole monistic theory must be surrendered. The answer is that *somewhere and at some time the organic world must have developed out of the inorganic.*

This is all we really *know*, but this we do know just as well as we know that the surface of the earth has undergone the changes which geology teaches that it has undergone. One of three things is certain: either organic life must have existed from eternity, or it must have been created specially, or it must have had a natural origin out of inorganic matter. The first of these contradicts all the facts of geology and all our modern ideas of the cosmogony of our system. The choice lies, therefore, between the other two, and for the consistent dysteleologist there remains no alternative.

Haeckel, however, is undoubtedly too hasty in many of his sweeping assumptions respecting this problem, as for example, that of the direct autogonia of his moners, such as

Bathybius Haeckelii of Huxley, who dredged it from the bottom of the Atlantic, where it exists in vast quantities as a strange, unorganized mass of living protoplasm. Even this would doubtless be too great a *saltus* for Nature to make. It is certainly far more in harmony with Nature's processes generally, and with the whole tenor of the monistic or genetic philosophy, to conceive that between the two divisions of archigonia which he establishes, autogonia and plasmogonia, there is in Nature a regular gradation, as throughout the rest of her domain, and that she first develops the plasma, that is, some combination of organic matter,

[47] consisting of the necessary | nitrogenized and carbon compounds in a high state of complexity and instability, and then, as a mere continuation of a uniform process, impresses this, first with the lowest and then with higher and still higher vital properties. For life is unquestionably a product of molecular organization.

While, therefore, inorganic matter must be regarded as the primordial ancestor of all organized beings, the first stage in the genealogical development of all living things, and hence also of man, must have been some form of *moner*. Haeckel enumerates eight genera of moners now existing on the globe, and there can be no doubt that there are many more still undiscovered, and their extreme and absolutely structureless simplicity renders it highly probable that they are really the first form of life which was developed on the globe.

532 | The direct descendants of the moners are undoubtedly the various forms of *amoeba*. About the only observable differentiation required to effect this transformation is the development of a nucleus in the interior of the protoplasmic substance of the former creature. This change converts the *cytod* into a true *cell*, and such is the character of the amoeba, a simple individual of the first order. According to Haeckel, neither the moner nor the amoeba can be strictly classed either with animals or with plants. They belong, together with many other lowly-

organized beings, such as the *Flagellata* or lash-cells, the diatoms, and the rhizopods, to his famous *third kingdom* the *Protista*. As moners, however, are the lowest of all forms of life, he divides these into three classes, animal moners, vegetable moners, and neutral moners. The first class develop into the lowest animal form, the *Protozoa;* the second into the lowest vegetable form, the *Protophyta;* and the third into the neutral form, the *Protista*. He also speaks of animal amoebae, and seems to regard these creatures more nearly allied to animals than to plants. At least, he places both the moner and the amoebae at the base of the animal scale, as the *first* and *second* terms of the phylogenetic series.

From the amoeba-group proceed the true Protozoa, which, therefore, stand in the anthropogenetic line. Applying now the biogenetic law to the *Morula-stage* of ontogenesis, we are able to conclude that these animal amoebas, at one period in their history of development, formed societies or compound individuals | (*Synamoebia*), which therefore constituted the corresponding *third* stage of development in the anthropogenetic line. [48]

There must have next existed, as the *fourth* stage, a family of creatures standing at the base of the protozoa, whose bodies consisted of a simple, hollow sphere, the walls of which were formed of a single layer of cells. These were the *Planaeada*, and they find their embryonic recapitulation in the blastosphere stage. These creatures are not yet so far extinct but that representatives of them still exist in Haeckel's *Mogosphaera*, in *Synura*, and in other marine and fresh-water forms.

The gastrula-form of embryonic development, barely traceable in the higher vertebrates, but common to both Amphioxus and Ascidiae, as well as to many lower forms, is all there is to warrant the assumption of a class of beings once peopling the waters of the globe, whose bodies consisted of a simple sac, open at one end, | and formed of two cellular layers. These were the interesting *Gas-* 533

traeada, which have given to all the forms that have descended from them the warp and woof of all their tissues, the primary germinative layers. They must have developed directly out of the *Planaeada*, and form the *fifth* stage in the descent of man.

Ontogenesis next points, as a *sixth* stage, to an extinct race of primordial worms, *Archelminthes*, which originated from the Gastraeada by the formation of an intermediary germinative layer, from which the two inner secondary layers eventually differentiated. These creatures belonged to the lowest subdivision of the worms, the *Acoelomi*, which, as their name implies, possess no cavity of the body (*coelom*) distinct from the sac-like stomach. They are also without any vascular system, heart, or blood, but manifest the first traces of the formation of a nervous system, the simplest organs of sense, and rudiments of secretive and reproductive organs. The typical representatives of the *Archelminthes* are the *Turbellaria*, but they also closely resembled the parasitic Trematoda and Cestoda, which belong to the group *Acoelomi*. Thus is man connected by blood relationship with the loathsome tapeworm that infests his stomach!

Out of the *Acoelomi* were developed the *Coelomati*, which, still low in the scale, nevertheless possess a distinct *coelom*. The now extinct race which effected this transition have been called the *Scolecida*, and form the *seventh* stage of anthropogenetic develop[49]ment. The precise interval which they seem to have bridged over lay between the *Turbellaria* and the *Enteropneusta*, the last of which are represented by the well-known *Balanoglossus*. From this point the great articulate branch swung off, and a little higher the important branch of the Mollusks.

To arrive at the *eighth* stage, we are again compelled to resort to the fundamental biogenetic law, and reason from the chordonium stage of embryonic development of all vertebrates to an extinct form, which must have possessed the rudiment of a vertebral column in the form of a *chorda*

dorsalis as a permanent character of its adult state. It would have been wholly impossible to say whether this assumed creature should be placed in the department of articulates, mollusks or worms, were it not for the flood of light which the anatomy of the Amphioxus and the Ascidian has, within the past few years, shed upon the whole problem.

The existence of such a *chorda* in the former of these animals, | and its presence also in the larval forms of the latter, are two facts which point unmistakably 534 to the type *Vermes* as the one which has furnished the transition to the *Vertebrata*. No creatures have been found in any of the other types which afford the least intimation of any such transition, and neither in the Protozoa, the Zoöphytes, the Echinodermata, the Crustacea, the Arthropoda, nor the Mollusca, has any trace of a *chorda dorsalis*, either in the larval or adult state, been detected after the most thorough examination. The conclusion is, therefore, irresistible, that the sub-kingdom Vermes and the class *Tunicata* have furnished the true progenitor of the vertebrates. This transition form itself has probably long been extinct, but it has left lineal representatives in the Ascidia, Phallusia, etc., which, while through long adaptation to a fixed existence during their adult state they have lost their *chorda*, still retain that distinctive character during their free larval state, as the unquestionable ontogenetic representative of an organ which they have inherited from their extinct chorda-bearing ancestor. This ancient and primordial ancestor of the vertebrate sub-kingdom to which so many facts, both of ontogenesis and of phylogenesis, with so great certainty point, Haeckel denominates the *Chordonium*. As if to put the solution of this important question beyond the possibility of a future doubt, it is now found that a member of this same group, the *Appendicularia*, actually preserves its chorda during life, | and this [50] creature may therefore be regarded as a living representative of the true *Chordonium*.

The Amphioxus forms the *ninth* stage in the anthropogenetic line, and furnishes the first link in the vertebrate chain. It is the only known representative of the once great subdivision of vertebrates called by Haeckel the *Acrania*, or skulless vertebrates.[10] Of this wholly unique and extremely interesting creature sufficient mention has already been made.

The *tenth* stage is that of the *Monorrhina*, or *Cyclostoma*, which have for their best-known representative the *Petromyzon* or lamprey. These arose out of the Acrania through a simple enlargement of the anterior extremity of the spinal nerve and the differentiation of the corresponding part of the *chorda dorsalis* into a rudimentary cranium. The distinctive circular mouth-orifice Haeckel regards as a mere adaptive character not present in the original progenitor of the *Craniota*.

535 | The transition to the *eleventh*, the Selachian or primordial fish-stage, took place through the formation of a pair of nostrils and a pair of jaws out of the simple, circular mouth-orifice of the *Cyclostoma*. This transformation led to the *Amphirrhina*, a branch of the *Craniota*, systematically coördinate with the *Monorrhina*, but embracing all the rest of the vertebrate sub-kingdom. With the higher fishes (*Ganoides* and *Teleostei*) human genealogy is not immediately concerned, but only with the lowest sub-class, the *Selachii*, whose present living representatives are few, and comprise the sharks, rays, etc., but which formed, in the Devonian age, the chief population of the waters of the globe, as their singular heterocercal remains, found in the rocks of that period, abundantly attest.

The transition from the Selachians was next to the *Dipneusta*, which constitute the *twelfth* stage. It was brought about by the natural adaptation of the organs of the body to a partially terrestrial existence. The swim-bladders were transformed into imperfect lungs, the nasal orifices, which in fishes have no communication with the

[10] See note 9, page [41] 364.

interior of the mouth, established such a communication, and the single auricle of the heart divided into two, thus correspondingly improving the circulation of the blood. The *Dipneusta* | therefore employed their gills, which [51] they retained, when in the water, but breathed through their lungs when on land. They form, therefore, a very anomalous and interesting transition group, connecting the lowest fishes with the lowest amphibians. They were a very large class in paleozoic time, as their dental remains testify, but at present only three genera are known, each with a single species, viz., *Protopterus annectens*, of the rivers of Africa; *Lepidosiren paradoxa*, of tropical America; and *Ceratodus Forsteri*, from South Australian swamps.

Gegenbaur has demonstrated that the real character of the fins of fishes is that of many-toed feet. The changes that led from the fish to the Dipneusta seem not to have affected the number of these toes, although a certain adaptation of the fins to terrestrial locomotion was perceptible. The next important transformation was to concern this part of the animal anatomy. The animals nearest related to the Dipneusta are unquestionably the amphibians, with which the former are frequently classed; but they differ from them in the important respect of possessing regular, five-toed feet. But one conclusion can be drawn from this fact, and this is that among the many and varied forms of the once great Dipneusta class, there | was one 536 whose locomotive organs had become transformed through adaptation and natural selection into five-toed feet, and that from this long extinct five-toed progenitor, the present amphibians have descended. The human embryo itself, and that of all the higher vertebrates, pass through an analogous transition.

With frogs, toads, and other higher amphibians, as we are most familiar with them, the anthropogenetic line has no direct connection. It constantly hugs the base of the whole group, exhibiting direct relationships only with the

Sozobranchia, which, therefore, form the *thirteenth*, and the *Sozura*, which form the *fourteenth* stage.

The former of these sub-classes comprises the *Proteus*, the *Siren*, and the *Siredon*, as among its best-known representatives, while to the latter belong the Triton and the Salamander. These once abundant but now comparatively rare creatures have furnished naturalists with some of the most interesting examples of what may almost be called the *visible transmutation of species*. It is well known that frogs and toads (*Anura*), the more highly differentiated amphibians, instead of possessing both lungs and gills | [52] during life, as do the Dipneusta, undergo a complete metamorphosis after birth, passing from a true fish-form, in the tadpole state (in which, in addition to the well-known external fish-like characters, they also possess gills and no lungs and a corresponding piscine circulation) to the familiar batrachian form, in which their respiration is through lungs only and their circulation through two auricles. Now, the two sub-classes above named furnish the most perfect and characteristic transition stages between the larval and adult stages of the higher amphibians. The Sozobranchia, as the term implies, preserve their gills through life, but also acquire lungs, and are therefore strictly amphibious. They live, however, chiefly in the water, and there perform all the functions of their existence. The greatest excitement in scientific circles has been recently called forth by the extraordinary conduct of a member of this group. The Mexican Axolotl (*Siredon pisciforme*) was observed in the Paris *Jardin des Plantes*, where large numbers of these creatures were kept, to frequently take to the land, and several individuals so far habituated themselves to terrestrial life that they actually lost their gills in the manner of the higher amphibians. Individuals thus behaving were scarcely distinguishable from the *Amblystoma*, a genus of the Sozura which acquire lungs.

| An equally remarkable phenomenon, but of ex- 537 actly the opposite class, was manifested by the Triton,

which belongs to the last named sub-class, and therefore habitually undergoes the metamorphosis common to frogs, etc., only without the loss of the tail. Before it arrives at maturity, the Triton, under ordinary circumstances, loses its gills and leads a sub-terrestrial life, breathing only air. But by placing it in a tank so shaped that it was unable to get out of the water, it was thus compelled to retain its gills through life, and even propagated in the water.

All animals above the amphibians are characterized by the possession, during their embryonic stages, of the important organ called the *amnion*, which is wanting in all below them, and in the amphibians themselves. The facts of ontogenesis, as well as those of comparative anatomy, justify the assumption of the former existence, probably in the beginning of the Mesozoic age, of a lizard-like animal whose fossil remains have not yet been discovered, and whose affinities with any known living form are not close, but which must have been the first to develop this particular organ, | and was thus the progenitor of all that now possess it, [53] and hence of man himself. This creature, which forms the *fifteenth* stage of man's genealogy, Haeckel calls the Protamnion. Out of it was developed primarily the great reptilian class, from which proceeded later the birds, with neither of which has man any direct connection. The origin of the mammals, however, must also be sought in the *Protamnion* stock, from which this class, too, must have proceeded, perhaps simultaneously with the reptilian branch, though in quite a different direction. The skull of all reptiles and birds is articulated to the atlas by means of a single condyle, while in mammals this condyle is double. From this circumstance the reptiles and birds have been designated by the common term *Monocondylia*. In them, also, the lower jaw is composed of several pieces, and movably joined with the skull by a special process, while in the mammals it consists only of a pair of pieces, and is immediately connected with the temporal bone. The further distinction between

the scales and feathers of the former and the hairs of the latter, is likewise an important one. The complete diaphragm of mammals, dividing the thoracic entirely from the abdominal viscera, and which is only partial in the *Monocondylia*, is a further very characteristic distinction. Finally, the existence of mammary | glands in the
538 latter, from which the class takes its name, and which are wanting in all other creatures, not only indicates a very distinct position for the mammals, but combines with other characters to place them at the head of the animal series.

A very distinct race, which Haeckel styles the *Promammalia*, forming the next or *sixteenth* stage of man's descent, must have developed out of the *Protamnia*, and transmitted all these marked peculiarities to the entire mammalian class. Man himself possesses all these special mammalian characteristics, and is therefore a genuine mammal.

The nearest known living representatives of these hypothetical *Promammalia* are the curious and remarkable *Monotremata* of Australia and Tasmania. Of the entire sub-class only three forms are known, the singular *Ornithorhynchus paradoxus* and the *Echidna*, of which there are two species, *E. hystrix* and *E. setosa*. These animals seem, at first sight, to form an immediate connecting link between the birds and the mammals, as they possess the beak of the former with the lacteal glands of the latter. They further
[54] | agree with the birds in having the anterior extremities of the clavicles united to the sternum, forming a sort of merrythought. A still more fundamental point of resemblance to the birds, and that from which the sub-class takes its name, is the possession of a common *cloaca*, the urinogenital duct opening within the body. The monotremes, however, agree with the mammals in all the characteristic attributes above enumerated, such as double occipital condyle, complete diaphragm, etc., while the cloaca, the merrythought, and other apparently avian characters, may have been inherited as well from the amphibians as from the birds. The beak, however, can only be accounted

for as having developed independently from adaptation to conditions of existence similar to those which evolved the toothless jaws of turtles, from which it is believed the beak of birds has been derived. The beak of the *Echidna* differs from that of the *Ornithorhynchus*, and exhibits an approach towards the snout of the ant-eaters. The beaks of monotremes and of birds must therefore be regarded as simply analogous, and not as homologous organs.

The Promammalia no doubt differed in many respects from the Monotremata, and Haeckel is inclined to believe that they possessed regular teeth, which the latter lost through adaptive modification. At least, the earliest fossil remains that paleontologists | have been able to refer with certainty to the mammals, and which occur in 539
the triassic formation, consist of teeth only. From a few small molar teeth found in Germany, and also in England, *Microlestes antiquus* has been constructed; and from similar dental remains found in this country, *Dromatherium sylvestre* has been described.

Although the Monotremata differ from the *Monocondylia* (reptiles and birds) in so many important respects in which they agree with the higher mammals, they, nevertheless, also present many points of difference with these latter. In addition to those already mentioned (cloaca, united claviculæ, etc.), the absence in these animals of any teats upon the mammary glands is very peculiar and anomalous. In consequence of this omission the only way in which the young are able to obtain their nourishment, is by a process of licking against the porous breast of the mother; and Haeckel, therefore, proposes as a synonym for the ordinary name of the sub-class, that of *Amasta*, or mammals without teats. | Again, the *allantoïs* is never transformed into a placenta, the *corpus callosum* is not developed, and [55]
there exists a pair of rudimentary marsupial bones. This last character affords almost conclusive proof of the descent of the marsupials from the monotremes.

The *Marsupialia* must therefore be regarded as the next

group of animals in the regular line of descent which terminates in man, and as forming the *seventeenth* stage in the development of the human race. Here the cloaca is divided by a horizontal partition into two distinct orifices, both opening externally; nipples are formed on the *mammae*, to which the young attach themselves, and the clavicles are distinct from the sternum. In these respects, the marsupials agree with all the higher mammals. The distinguishing character in which they differ from them, and that from which the name of the sub-class has been taken, is the existence of a remarkable pouch or sac (*marsupium*) on the under side of the female, in which the young are placed at a very early period, and there retained until they are able to take care of themselves. This pouch has been aptly likened to a second or supplementary uterus, and the marsupials have accordingly been called by some *Didelphia*. Our well-known opossum (*Didelphys opossum*) is our only North American representative; but in Australia, this group of animals constitutes the greater part of the mammalian fauna.

The absence of a placenta is the only other important
540 particular | in which the marsupials differ from the higher mammals. Indeed, the marsupium seems to constitute a sort of substitute for a placenta, and the want of the latter may be regarded as the physiological cause of the development of the former. The monotremes, however, are without either, and are oviparous, like birds and reptiles.

The so-called true *Mammalia* all possess a fully developed placenta, and are therefore distinguished from the two groups last mentioned as forming a third sub-class, the *Placentalia*. This organ is of great importance in the classification of the higher mammals, its mode of attachment furnishing excellent and reliable general characters. In some, for example, the placenta is deciduous from the inner wall of the uterus, while in others it is not, and on this distinction is based the primary division of the whole sub-class into the *Deciduata* and the *Indecidua*. The latter

are the least perfectly organized, and comprise the Edentata, the Cetacea,| and the Ungulata. In man the placenta is deciduous, and he can therefore have descended [56] from none of these.

The *Deciduata* again fall into two divisions according as the embryo is attached by the placenta to the uterus upon a single small area or disk, or by a band or girdle extending entirely around it. The former are called *Discoplacentalia*, the latter *Zonoplacentalia*. The *Zonoplacentalia* embrace the *Carnaria* (*Carnivora* and *Pinnipedia*) and the *Chelophora*, to which the elephant belongs. The *Discoplacentalia* comprise the rodents, the *Insectivora* (moles, etc.), the *Chiroptera* (bats), the lemurs (*Prosimiae*), and the apes (*Simiae*). To this last legion, also, belongs man, who differs in this respect not at all from the mouse, mole, bat, lemur, or ape.

Now it is a remarkable fact that in one order of the marsupials, the *Pedimana*, embracing the two families *Chironectida* and *Didelphyida*, to the last of which our opossum belongs, the hind feet are modified, in a peculiar way, into organs for grasping, resembling hands. This group can therefore only be regarded as exhibiting the earliest marks of that important course of transformation which culminated in the apes and in man. The course of development was from this group of marsupials directly to one within the *Deciduata*. Leaving all other animals wholly out of its course, the line of descent of man passes immediately from the *Marsupialia* to the *Prosimiae* or lemur group, an order which Haeckel takes out of Blumenbach's *Quadrumana*, because it is so much farther sep|arated from the other apes 541 than any of these are from one another. They are apelike creatures, but shade off in a very interesting way into nearly all the remaining orders of the *Discoplacentalia*. The *Chiromys Madagascariensis* forms the transition to the rodents; the *Galeopithecus* of the Sunda Islands, to the bats; the *Macrotarsi*, to the insectivora; and the *Brachytarsi*, particularly the Lori (*Stenops*), to the true apes. They also

exhibit close affinities to the Sloths (*Bradipoda*), which have been regarded as an order of the *Edentata* in the Indecidua; but recent investigations have proved that they have a deciduous placenta, and therefore it must be at this point that the Deciduata and the Indecidua join. The lemurs are harmless and melancholy nocturnal animals of a graceful form, and are chiefly confined to the islands south of Asia and east of Africa, and particularly to Madagascar. Their frequency on the islands of the Indian Ocean led the English
[57] naturalist Sclater | to name this once continental, but now mostly submerged region, *Lemuria*, a circumstance to which Haeckel has given special prominence, by pointing out the many facts which conspire to justify us in the conjecture that here may have existed the true "cradle of the human race." The lemurs form the *eighteenth* stage in the anthropogenetic line.

From the lemurs to the true apes, the transition is comparatively easy. They evidently developed out of the *Brachytarsi*, the *Stenops* forming the nearest approach to a connecting link.

Linnæus, with almost prophetic ken, notwithstanding his dualistic proclivities, classed man with the apes, lemurs, and bats, in his celebrated order, Primates. Blumenbach fancied he saw in the human foot a pretext for rescuing man from this association, and accordingly erected for him a separate order, which he called *Bimana* (two-handed), distinguishing the apes, etc., as *Quadrumana* (four-handed). This classification was adopted by Cuvier, and is the one which has generally prevailed among naturalists down to Huxley and Haeckel. Huxley, however, gave the whole subject a complete re-investigation, and arrived at the conclusion that Blumenbach's order *Bimana* cannot be maintained on anatomical grounds. He shows, in the most convincing manner, that the distinctions alleged to exist between the posterior hands of apes and the feet of man are apparent only, that they were based on *physiological* and not on *morphological* considerations. The apes are just

as good bimana as men are, and men are just as good | quadrumana as the apes. In neither are the posterior limbs in all respects homologous to the anterior. The 542
tarsal bones are differently arranged from the carpal bones, and there are three distinct muscles serving to move the foot that are wholly wanting in the hand. But all this is as true of the apes as of man. The limited opposability of the great toe in man is only a functional distinction. The muscles of opposability are all present; they are merely atrophied by disuse and adaptation to altered conditions. Traces of this power are found in many savages, who hold on with their toes to the branches of trees in the forests where they live, and otherwise employ this posterior thumb in a variety of ways which Europeans cannot imitate. There are, moreover, many instances on record of men acquiring extraordinary dexterity in the use of their toes. Every one in this country has seen the exhi|bitions of [58]
the armless man, who travelled through our towns and displayed marvellous feats performed with his toes. Again, infants make far more use of their great toes than adults do. Watch a new-born babe as it lies in its cradle and amuses itself with exercise of its muscular activities; compare the movements of its hands with those of its feet, and you cannot but be struck with the comparative indifference with which it manages both. The human foot, whose careful study has been said to constitute a sure cure for atheism, and whose wonderful adaptation to the purpose to which it is applied has been regarded as an unanswerable argument for the doctrine of design, can therefore be nothing more than a natural result of the modification of the posterior hand of the ape, in simple obedience to the mechanical law of adaptation to changed conditions, while in it are found all the visible elements of that ancestral organ which the equally monistic law of heredity has transmitted from our simian progenitors. Huxley, therefore, restores the Linnæan order *Primates*, removing only the *Chiroptera*. Haeckel, however, would

adhere to his order Prosimiae, the lemurs, for the reasons above stated.

The true apes are primarily divided into two great groups, which are as distinct geographically as they are anatomically. These are the *Catarrhinae* or Old World apes, and the *Platyrrhinae*, or New World monkeys. They differ chiefly in two important respects. The *Platyrrhinae* have a flat and broad nose, like other animals. The nostrils open *outwardly*, and are separated by a broad interval. They have, also, thirty-six teeth, eighteen in each jaw. In both these respects | they *differ* from man. The
543 *Catarrhinae*, on the other hand, have a somewhat projecting, laterally compressed, and often arched or aquiline nose, with the nostrils close together and opening *downwards*. They have only thirty-two teeth, or sixteen in each jaw. In both these respects they *agree* with man. The clear-cut, much projecting, and elegantly formed nose of the Nose-ape (*Semnopithecus nasicus*) would adorn the face of any European nobleman, while the countenance, taken in its *ensemble*, of *Cercopithecus petaurista* would be sure to call to any one's mind some not very bad-looking person of his own acquaintance. And yet these handsome apes are endowed with long tails. Not only is the number of the teeth of the *Catarrhinae* the same as in man, but they
[59] are distributed in precisely the same manner, namely, | four incisors, two canine or eye-teeth, and ten molars or grinders, in each jaw.

The *Catarrhinae* are further divided into two groups of tail-bearing and tailless apes. The tail-bearing apes have most probably been developed directly from the lemurs, and therefore constitute the *nineteenth* stage in the descent of man. Our ancient forefathers in this group were perhaps similar to the now living *Semnopithecus*, from which the tailless apes, forming the *twentieth* stage, were differentiated chiefly by the loss of their tail. These latter bear the greatest resemblance to man, and are called anthropoid apes, constituting the family *Anthropoides*. The family

consists, as far as known, of but four genera, *Hylobates*, the Gibbon of southern Asia; *Satyrus*, the Orang of Borneo and the Sunda Islands; *Engeco*, the Chimpanzee of southern and western Africa, and the Gorilla, first discovered by the missionary Wilson, in 1847, on the Gaboon River, western Africa, and afterwards by Du Chaillu. The Gorilla is the largest of known apes, and exceeds the human stature.

To none of these four anthropoid apes, however, can we point as being in all respects the nearest to man. The Gibbon resembles man most in the form of the thorax, the Orang in the development of the brain, the Chimpanzee in the formation of the skull, and the Gorilla in the differentiation of hand and foot, and also in the relative length of the arms. It is therefore evident that man cannot have descended directly from any known living ape. His real progenitor must, in a greater or less degree, have combined all these characters, and has no doubt been long extinct. It is from paleontology that we alone hope for aid in the discovery of this "missing | link." The fossil remains of this extinct genus (*Pithecanthropus*) may 544
be looked for with some confidence in the still little known region of southeastern Asia, the Malay Archipelago, and throughout central and western Africa.

The comparative anatomy and osteology of these four genera of anthropoid apes have been exhaustively studied by Carl Vogt, Huxley, and others. The final conclusion to which Huxley comes, and which he expresses in the most unqualified and emphatic manner, is that, no matter what system of organs we take, a comparison of the modifications in the Catarrhine series leads to one and the same result: that the anatomical differences that distin|guish man [60]
from the Orang, Gorilla or Chimpanzee, are not as great as those which distinguish these latter from the lower *Catarrhinae* (*Cynocephalus*, Makako, *Cercopithecus*). Therefore as Haeckel remarks, it is incorrect to say that man has descended from the apes; *he is himself an ape*, and belongs as strictly to the Catarrhine group as the Gorilla or the Orang-

outang! He therefore establishes another family within that group, together with the *Anthropoides*, which he calls the *Erecti* or *Anthropi*. This family he divides into two genera, the first embracing the now extinct ancestor of the human race, the *Pithecanthropus* or ape-man, which therefore forms the *twenty-first* genealogical stage, and the second being the genus Homo, or man as we find him, forming the *twenty-second* and last stage in his development from the moner.

Three anatomical distinctions of any importance are all that exist to separate the two families *Anthropoides* and *Anthropi*. One is the more erect posture of the latter—a difference of degree, however, which varies both with the apes and with men. The second is the higher brain development of the latter, which is also only a quantitative distinction. The third and only distinction which can be called qualitative, is the differentiation in the Anthropi of the larynx into an organ of speech. And not even this much can now be fairly said, since it is found that the larynx of monkeys exhibits a much higher state of development than that of other animals.[11] Haeckel, however, regards *Pithecanthropus* as a speechless man, having the erect posture and differentiated brain, but who had not yet acquired the power of articulate language, or the necessary organs for its utterance. For this reason | he
545 offers also a synonym for his name *Pithecanthropus*, the equally appropriate one, *Alalus*, the speechless. This, however, is only theory. In point of fact, the erect posture, size and quality of brain, formation of vocal cords, and the origin of articulate speech, must have all advanced *pari passu*, mutually promoting one another, and developing by insensible degrees, according to the universal method of all nature.

To the various races of men as recognized by ethnologists, Haeckel, in harmony with his general system, gives the

[11] Emile Blanchard, *Voice in Man and Animals*, in *Popular*
544 *Science Monthly*, September, 1876, page 519.

rank of *species* of the genus Homo. All definitions of the term species | having failed to unite upon any absolutely constant character as a condition to its application, the use of it here is justifiable, notwithstanding the ease with which the human races hybridize, and no matter what theory may be preferred of their origin or relationships. Of these species he makes out twelve, and advances an interesting theory of their origin and geographical distribution over the globe; but upon this new field we can here follow him no farther. [61]

In casting a retrospective glance over the vast subject thus hastily passed in review, there are a few salient points which will have most probably, in an especial manner, struck the mind of the reader.

One of these is likely to be the great brevity of the anthropogenetic line, considering the variety and multiplicity of living forms found on the globe. We perceive that of the seven sub-kingdoms of animals now recognized, only three are touched by it, viz., the Protozoa, Worms, and Vertebrates. The zoöphytes, echinoderms, arthropods, and mollusks all branch off either below or at the worm stage, and the transition from the *Tunicata*, a worm-form, is direct to the vertebrata. This, when adequately appreciated, is an astonishing fact, and one which would never have been conjectured but for positive anatomical evidences. Those who believed in a law of development were looking vainly for proof of the derivation of the different types one out of another, and discussing which should be considered lowest, the articulates or the mollusks. They expected to find proof of a series with the radiates at the bottom and the vertebrates at the top. The truth, as it has at last dawned upon us, dispenses with all such speculations.

Equally surprising is the shortness and directness of the transition from the lowest to the highest vertebrates, | from the Amphioxus to the Ape. All the vague surmises of some extensive course of descent and lineal 546

relationship among the numerous classes and orders of vertebrates are now also brought to an end. The higher fishes and higher amphibians, the reptiles and the birds, are all left to pursue special routes of their own; and a brief series of easy and rapid transitions through the lowest fish-form, the *Selachia*, and the lowest amphibian-forms, the *Sozobranchia* and *Sozura*, brings us at once to the lowest mammalian stage. [62] | But perhaps the most surprising part of this whole course is its one great stride through the entire mammalian class, from the marsupial to the lemur. All vain expectations of finding some thread of relationship that should lead through the labyrinth of varied mammalian orders, and connect us with the horse, the dog, the elephant, etc., are thus happily set at rest, and we are permitted only to claim such consanguineal relationship with the opossum, the lemur, and the ape.

In fact, instead of a long concatenated "*chaîne animale*," as Lamarck supposes, the animal kingdom presents rather a tree, spreading from very near the base with almost a whorl of unequal branches or subordinate trunks, each of which is again variously branched, giving the whole the form of an inverted cone or pyramid. At the upper extremity of each of these branches, which have come a long way independently of each other, is found one of the great groups or types of now living creatures, man occupying the highest summit of the vertebrate branch.

Contemplating now the great number of branches that arise at different points, some of which are short and apparently stunted, while others push upward with different degrees of vigor, only one or two reaching truly lofty and commanding positions, the thought forcibly strikes us that this picture reveals the universal tendency of Nature to develop organic forms. We realize that this vital force or *nisus* is constantly pressing at every point, but that, as the conditions of life are limited, success is possible only at a few points; that in consequence of obstacles of many kinds, not the least of which are offered by organic conditions them-

selves that have preoccupied the field, the degree of success at these points varies widely, and produces all grades of vigor, size, length, and ramification among the branches. The highest and most thrifty branches mark the line of absolutely least resistance; the shorter and less vigorous ones indicate lines offering varied degrees | of resistance; while the stunted, dwarfed, and retrograde 547
branches show lines of resistance so great that the vital force barely overcomes it. Finally, all points from which no buds or branches arise teach us over how large a proportion of nature the resisting agencies wholly overbalance the organic tendencies, and no life can originate.

Another thought to which the attentive contemplation of this | theme gives rise, is the greater antecedent [63]
probability of like organs, occurring in different animals, being *homologous*, than of their being *analogous*. The conditions in which life finds itself placed are so infinitely variable, that the chances are almost infinity to one against the development of the same organ independently at two different times and places. Where the same organ is unexpectedly found in two animals which had not been supposed to be at all related, it affords the strongest evidence that they are either immediately connected by blood, or at least that they have both descended from a common ancestor that possessed that organ. Hence the irresistible force of the testimony afforded by the so-called "rudimentary organs," which none but those who realize this important law can properly appreciate. That analogues do sometimes occur, in obedience to the law of adaptation, cannot, however, be denied; but they usually betray their origin by being formed on an essentially different principle, though in such a manner as to accomplish the same purpose. The wings of birds, bats, and insects are such cases of analogy, in each of which the morphological differentiation is wholly different, while the physiological function is the same. The beak of the Ornithorhynchus is perhaps as near an approach as we have

to a true morphological analogue, the descent of that animal from the birds being overruled by a preponderance of evidence against it.

It is this principle, too, which conclusively negatives the presumption which some have advanced, that the aborigines of America may have descended from the New World monkeys. Catarrhine man could never have sprung from a Platyrrhine ape.

It is, moreover, this same biological law which justifies Haeckel in the assumption of so many hypothetical and long-extinct ancestral forms, although no warrant for them is afforded by paleontology. The Gastraea, the Chordonium, the Protamnion, the Promammalia, and the Pithe-
548 canthropus are all creatures, not of his imagination, but of stern logic, based on a profound famil|iarity with all the facts and principles that bear upon the problem. The common origin and blood relationship of all creatures that possess a spinal column, of all that are endowed with five-toed feet, of all that develop an amnion, of all that have the double occipital condyle, of all that suckle their young, of all having the fore and hind feet differentiated into hands,
[64] of all that have the catarrhine nose | and identical dentition—these are propositions whose demonstration, by the aid of the law of heredity, is as complete and absolute as that of any proposition in Euclid. There is no other way to account for these facts. The chances of these organs being so many independent morphological analogues, produced by adaptation to identical conditions, are but as one to infinity.

Either the dualistic conception of teleological design, *i. e.*, miracle, must be admitted, or else there is no alternative from this explanation.

86. Timber-trees of the Dismal Swamp

History. — Written June 14–15, 1877. The trip through the Dismal Swamp was made in company with the two well-known botanists, Prof. J. W. Chickering and Mr. Thomas Morong, on May 14–16, 1877. We employed an old colored man known as "Uncle Eli," who had lived around the swamp all his life and had in ante-bellum times concealed in it many a fugitive slave. He had an excellent "dug-out" that easily carried us all with our belongings. The two nights and three days spent in the swamp constitute one of the most weird and interesting experiences of my life. I wrote the whole subject up in quite an elaborate article, entitled: "A Visit to the Dismal Swamp," which I never was able to get published, and it is still among my unpublished writings.

Field and Forest, Washington, D. C., Vol. III, No. 2, August, 1877, pp. 29–31.

DURING a recent excursion made by a party of botanists from Washington to and through the Dismal Swamp of Virginia, the growth of timber-trees was carefully noted, and I submit the following list

of all the species observed to attain a height of twenty feet or more and a diameter of four inches and upwards, together with the subjoined remarks.

Magnolia glauca, L.	Fraxinus Americana, L.
Liriodendron Tulipifera, L.	Fraxinus viridis, Michx.
Rhus copallina, L.	Ulmus fulva, Michx.
Acer rubrum, L.	Ulmus Americana, L.
Liquidambar Styraciflua, L.	Ulmus alata, Michx.
Aralia spinosa, L.	Quercus aquatica, Catesby.
Nyssa multiflora, Wang.	Fagus ferruginea, Ait.
Nyssa uniflora, Walt.	Myrica cerifera, L.
Oxydendrum arboreum, DC.	Salix nigra, Marsh.
Ilex opaca, Ait.	Pinus Taeda, L.
Ilex Cassine, L.	Cupressus thyoides, L.
Diospyros Virginiana, L.	Taxodium distichum, Richard.

It is not of course pretended that the twenty-four species here enumerated constitute all the trees growing in the Dismal Swamp, perhaps not all that might have been detected if none had escaped our observation, but it is believed that the list could not be very considerably extended without pursuing other routes through the Swamp than that followed by our party, which was through Jericho, Feeder, and the Dismal Swamp Canals, and around the northern and eastern shores of Lake Drummond.

To many this list will appear remarkable for what it does not contain. The absence of oaks (*Q. aquatica* excepted), of hickories and other *Juglandaecae*, of *Platanus*, *Celtis*, *Morus*, *Betula*, and *Populus* was certainly not to be expected, yet if any of these trees inhabit the Dismal Swamp they are nowhere abundant or common. This list, however, as in all such cases, conveys a very inadequate idea of the real character of the timber of the Swamp. This is due to the great prev|alence of some, and paucity of other species. In point of fact the bulk of the timber is comprised in the four following species, named in the

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order of their abundance: *Nyssa multiflora*, *Cupressus thyoides*, *Pinus Taeda*, *Taxodium distichum*. After these would follow as very common trees, the tulip (poplar), the beech, the swamp maple, the sweet gum, and the elm. Of small trees *Ilex opaca*, *I. Cassine* (the Yaupon), and *Magnolia glauca* are the most common, of which the first and also the last named often assume the dimensions of true forest trees. *Quercus aquatica* was common on the drier grounds along the Dismal Swamp Canal and presented the most extreme variations of leaf, ranging from bluntly trilobate with a wedge-shaped base to linear-lanceolate and entire, as in *Q. Phellos*, but with every describable form of sportive irregularity in the lobation.

Aralia spinosa and *Myrica cerifera* were abundant, but only rarely appeared as proper trees. *Rhus copalina* attained an extraordinary size, and might almost be regarded as a tree. *Nyssa uniflora* was rare and no fertile trees were found.

The bald cypress, though abundant, is not a prevailing tree, and the Dismal Swamp cannot properly be called a cypress swamp. It is most common round the shores of the lake, and there exhibits its characteristic habit of throwing up "knees." The great wealth of the swamp is *Cupressus thyoides*, there known only by the name of "juniper." It occurs in what are known as "juniper swamps," which are often of vast extent and in which scarcely any other trees are found. The great durability and other valuable qualities of the wood of this tree are well known, it being the same as the "white cedar" of the north. These juniper swamps sometimes take fire and burn out in dry seasons, the fire often extending for some distance down into the peaty soil and completely destroying large areas of this valuable timber. We passed through one of these large "burnt tracts." The earth below the surface in these juniper swamps is said to be filled with the trunks and roots of the trees of past ages in a perfect state of preservation, and the business of exhuming them has been undertaken

with success and will doubtless be carried on after the supply of standing timber shall have been exhausted. At present a great many railroad ties and shingle blocks are being cut and taken out, through both the Jericho and Dismal Swamp Canals.

31 | Alternating with these juniper swamps, and occupying considerably more territory, are the so-called "gum swamps," of which the prevailing tree is the black or sour gum (*Nyssa multiflora*). This is, however, less exclusive than the "juniper," and with it are associated nearly all the other species above enumerated. These gum swamps usually constitute majestic forests, the trees attaining a great size and the foliage being dark and umbrageous. *Tillandsia usneoides* grew sparingly on *Nyssa* and *Taxodium*, and *Phoradendron flavescens* seemed to have complete possession of the former of these trees; it was also observed on the maple. *Polypodium incanum* was common on the elm, but not being a parasite it did equally well on dead and prostrate trunks.

September, 1877—Ætat. 36.

87. Central Flowers of Daucus Carota

History.—The principal observation was made on July 22, 1877, and is duly recorded in my field botanical note-book of that date. The note here is merely an expansion of the field note.

Field and Forest, Washington, D. C., Vol. III, No. 3, September, 1877, p. 53.

I HAVE observed *Daucus Carota*, the wild carrot, this season with some care and find that there is considerable difference in the central flower of the umbels. In some it is wanting entirely and in others it is only rudimentary. In one place I found it raised to some distance above the umbel on an elongated pedicel; this pedicel bore a sort of involucre below the base of the flower which was united into one piece at its base and appressed to the pedicel. The bright purple flower in these cases seemed to be perfect, dissection revealing five plump stamens full of healthy pollen grains, two styles, and a two-celled ovary, each cell containing an ovule (*mericarp*).

September, 1877—Ætat. 36.

88. Pinus pungens in the District of Columbia

History.—Written July 25, 1877. The discovery was made July 22d. I afterwards found a single specimen in the Soldiers' Home Grounds (Harewood), and later saw it on Oxen Run, Md., and at Clifton, Va., near Bull Run. The principal locality is now fortunately within the Rock Creek National Park.

Ibid.

THE discovery of *Abies Canadensis* at Great Falls was thought quite remarkable by some, but that *Pinus pungens*, the table mountain pine, should be found within the District of Columbia is doubtless more than would have been believed by the veteran botanist of Washington. In a fine wood which skirts Rock Creek above Blagden's Mill stand some dozen trees of this species. They are from 12 to 18 inches in diameter, and grow tall and handsome. They are surrounded by trees of the yellow pine, *P. mitis*, with which they contrast plainly in general habit, in the scaly bark, in foliage, etc., but particularly in their many times larger cones, which render them conspicuous objects from a distance. The persistent bases of nu-

merous decayed limbs at all distances from the ground is a noticeable peculiarity in the general habit of these trees, and one of which I gladly availed myself in climbing one of them in order to secure fine specimens of new cones just formed. There is room for speculation as to how these few mountaineers have condescended to mingle with the humbler growths that make up the *Flora Columbiana*.

September 22, 1877—Ætat. 36.

89. Cosmic and Organic Evolution

History.—Written April 18 to 29, 1877. I was writing Chapter II of *Dynamic Sociology*, reviewing Herbert Spencer's *Synthetic Philosophy*, and it occurred to me that he was confounding two quite different processes. I have never since been able to see it in any other light, but all apparent difficulties disappear in the light of my later-discovered principle of synergy, which, however, is clearly stated here.

The Popular Science Monthly, New York, Vol. XI, October, 1877, pp. 672–682.

THE evolution of a world is not obviously identical with the evolution of an organism. From one point of view they may be regarded as, to a certain extent, opposite processes. Fully understood, they are different manifestations of one process, affected by very different circumstances. Regarding each as an aggregate which must equally run its course, the special histories of the two are quite unlike. The history of every aggregate consists of two parts, a rise and a decline. It has its period of growth and its period of decadence. The first consists in a gradual progress from a diffused toward a concentrated

state; the second is the return from the concentrated to the diffused state. The process involved in the first period is the integration of the matter of the aggregate, and the dissipation of its motion. In the second period this process is reversed: its matter is disintegrated, and motion is evolved. The first of these processes is termed evolution; the second, dissolution. In theory this is identical in all aggregates, and therefore the life-history of a plant is the same as that of a star.

But, while we may trace and understand the process in the former of these aggregates, and may declare such to be its law as the result of more or less accurate experimental proof, this is not the case with the latter. We see the varied forms of life spring into being and vanish out of being. We may watch them during their entire history, from the moment when they emerge from the imperceptible to that in which they are again lost in the imperceptible. We can ob|serve all the processes of concentration, of differ- 673
entiation of parts, and of integration of the whole, as well as those of equilibration, of decomposition, and final dissolution. Not so with the planet. Whatever theory may suggest or require, we are forced to confess a profound ignorance of the final destiny of worlds. So far as we are able to observe, the universal tendency of all matter is from the indefinite and homogeneous to the definite and heterogeneous; from a state of unstable to one of stable equilibrium. But this is only the morning of the life of any aggregate. We have no reason to suppose that, in all the myriad worlds of visible space, a single star presents to our gaze a condition representing the evening of its life. In the light of all our knowledge of the heavenly bodies and of the nebulæ, we study with absorbing interest the history of our own planet. From the confused gaseous condition in which it is supposed to have originally been, its motion has been gradually dissipated and its matter integrated, until only a comparatively thin envelope of gas—the atmosphere—remains. The rest has all assumed either the liquid or the solid form,

the latter of which presents the nearest approach to complete stable equilibrium. And it can scarcely be doubted that this process still continues, and will continue, until ultimately this omnipresent *eremacausis* shall also reduce the waters and the atmosphere to the condition of stability and solidification—a state of planetary existence which many suppose our satellite to have already reached.

And may not this same law be called in to explain the heterogeneity of elementary matter, as known to chemistry? If all matter is primordially identical, as so many philosophers have dreamed, is it not philosophical to assume that our sixty-five known elements represent so many states of heterogeneity, so many distinct kinds of primary aggregates, which the matter of our globe and other worlds has taken on in its course from complete homogeneous instability toward its ultimate condition of stable equilibrium, as represented in what we know as solids?

However this may be, it is at least true that, so far as regards purely cosmical processes, the ascending series is the only one observable by us. For the "dead star," be it understood, represents, in the grand cycle of the redistribution of matter and motion, the *meridian* of its life, and not its close. Complete equilibration is the last act in the drama of evolution, and must be attained before the forces of dissolution commence their work. But we look in vain for any signs of the dissolution of the universe. Whatever theory may require, the fact ever remains that the process which we see going on in our portion of space is the process of evolution only. We see only the integration of matter and the dissipation of motion. We see only the tendency toward the condition of stable equilibrium. We see only the absorption of the gaseous and the establishment of the solid form of matter. All the theories by which it has been sought to compen|sate for the radiations of luminous bodies have proved mere speculations. We know that the sun is radiating its heat into space; we do *not* know that space is returning this dissipated motion, either

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to the sun or to any other centre. We see planets and stars in various stages of their progress toward the stable state; we have no reason to believe that any are in the condition of transition from the stable to the unstable state.

The moon is supposed to have already passed through most, if not all, of its stages from the gaseous to the solid condition. Its atmosphere has been absorbed, its waters have retreated into its interior or perhaps been converted into solids, and all its visible activities have apparently ceased. If there still exist volcanic activities upon it, as certain observations seem to prove, they are probably the only ones, and are themselves declining. Doubtless there are other bodies in our solar system whose equilibration is even more complete than that of the moon—as, perhaps, some asteroids, or the satellites of the outer planets. They have run their long cosmical course, and have arrived at last at the final state of complete, stable equilibrium. This state is the goal of the whole process of evolution. It must, therefore, be regarded, when viewed from this standpoint, as the state of greatest perfection in the life of every aggregate. Many of the heavenly bodies have certainly advanced far toward this condition, and all are undoubtedly approaching it. But where is the evidence that any have commenced to reverse this process? What star is suspected of being in a state of disintegration? Where in all the universe do we see solids turning into liquids, and liquids into gases? Where and how are the radiations emitted by concentrating bodies being harvested again, and applied to the disintegration of completely integrated matter? In a word, amid all these manifest proofs of evolution, what proof exists of dissolution regarded as a cosmical process? We are bound to confess that there is none. We are justified in its assumption on *a priori* grounds alone, if at all. The law of the conservation of energy, now so well established in all the departments of physics, must be theoretically extended to the mechanics of space. This law is only another expression for the indestructibility of motion.

If no motion can be destroyed, the same quantity must always exist in the universe. And as motion is necessarily nothing more than the local change of material atoms, all the solar and astral radiations must continue for all time to affect the same quantity of matter to the same extent. Hence these radiations cannot be wholly lost. Still, all this may be true, without affecting the question of the dissolution of worlds. The minute fraction of the sun's heat which is intercepted and absorbed by the different bodies of the solar system is utterly insufficient to ever effect their disintegration; and it is continually diminishing as the sun itself approaches the term of its existence: *a fortiori*, no such results can ever be produced by any of the more
675 remote | radiating bodies. All this motion is projected into space, and the history of its future work is wholly beyond our comprehension. It may continue to affect the ethereal atoms pervading space for all eternity, without exerting an appreciable influence upon concentrated matter. Even our right to project the law of conservation into the realms of space, where we daily see motion dissipated but never recomposed, has been called in question. Have we the right to assert that this motion, lost to our system, is not lost to the universe? True Science well knows how here to suspend its judgment, but it also knows how to restrain the hopeless cry of *ignorabimus*.

Mr. Herbert Spencer is therefore right in making evolution the fundamental principle of philosophy, and regarding dissolution, which is its exact opposite and correlate, as practically of very inferior importance. For, so far as the earth itself and the heavenly bodies are concerned, the very existence of such a process is in doubt. So far as our knowledge of the universe, as such, extends, but one law is anywhere observable, and that is the law of evolution. Indeed, evolution is but the process of which the principle is gravitation. Evolution is the concentration and integration of matter; its tendency is toward the condition of stable equilibrium. The *con*traction of a body is due to the

*at*traction of its molecules. Gravitation alone can explain this tendency, and gravitation necessarily requires it. Evolution is therefore coextensive with gravitation. Wherever gravitation prevails, evolution must prevail. On the contrary, a condition of dissolution would require the prevalence of a force the reverse of gravitation—a repulsive and expansive force. Our acquaintance with the visible universe reveals no region of space where we can assume the prevalence of such a force. On the contrary, many fixed stars, and even nebulæ, afford the strongest evidence of being under the dominion of an attractive force. Not, however, but that there exists in the universe abundant evidence of the possibility and reality of a repulsive or dissolving force. This is found, and with the greatest certainty, within the scope of our daily observation of the facts about us. And in at least one instance it is assumed, with a high degree of proof, to manifest itself in regions beyond the limits of terrestrial influence. I refer to the behavior of the tails of comets at perihelion. But wherever we see this force of repulsion, which alone could effect the dissolution of the aggregates already formed, it is wholly subordinate to the force of attraction which has formed them. Phenomena of this nature are but episodes in the history of a system or of a world. Everywhere the opposite phenomena predominate. Everywhere the force of gravity is evolving new aggregates, and bearing old ones on to their final state of complete equilibration.

Let us now turn to the second branch of our subject, and glance for a moment at the phenomena and laws of organic evolution. The first fact that presents itself is, that its primary condition is the influence of the sun. However it may have been at one period of the history of the earth, when its internal temperature may have been of a nature to favor the development of organic life without the sun's aid, by the earth becoming itself a sort of sun, it may at least be now affirmed that the solar radiations are the sole condition of vital existence on the globe. This fact is so

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apparent that even savages have generally recognized it, and science has scarcely been able to qualify the popular conception. By the aid of the sun's heat and light the various forms of vegetable and animal life have been evolved. By the same influence, year by year, the buds, and flowers, and leaves, unfold to the elements, and renew their conditions of growth and reproduction. By means of it the waters of the globe are in part converted into vapor and gas, in which state alone they are adapted to the supply of organic beings. By its influence the various organic bodies on the surface of the earth are finally disintegrated, and the materials for new forms and new beings are dissipated into the gaseous form, for recomposition and reutilization. By the same influence the waters of the globe are prevented from solidifying, and made the abode of millions of organic beings. In a word, it is the influence of the sun which alone renders our planet a habitable globe.

But what is the nature of this great and wonderful influence as expressed in the terms of the redistribution of matter? However paradoxical it may seem, it is nevertheless true that the great life-creating and life-sustaining force of the sun is cosmologically a *disintegrating* force, a force of *dissolution*. Indeed, the solar and sidereal radiations are the only examples which the whole universe presents to us of such a force. It seems strange enough to be compelled to ascribe all the phenomena which have been embodied in the term organic evolution to the action of a force which is the precise opposite of evolution, and which ultimately accomplishes the dissolution of every such aggregate. Yet it is only because the sun is in a state in which its matter is being integrated, and its motion radiated into space, that our earth is capable of producing the forms of organic life. It is only because a portion of this motion, ejected from the sun, is intercepted and absorbed by the earth, by which a portion of its own matter is disintegrated, and its own course of evolution is in so far arrested, that the presence of the beings peopling it has been made possible.

It is only through cosmical dissolution that organic evolution can go on.

Is life, then, a process of dissolution? Is organic evolution a misnomer? Are the unfolding of the bud, the branching of the tree, the hatching of the egg, the differentiation of the animal—are these but so many steps which concentrated matter is taking toward its final disintegration? Is development the antithesis of evolution? To all these questions a negative answer may, I think, be given. But we have gone far enough to perceive that some broad distinction exists between | cosmic and organic evolution. 677
Let us examine this distinction more closely. We know that an organism develops, much like a world, out of a homogeneous and diffused state of its elements. Throughout its course the organic aggregate behaves like other aggregates. From the imperceptible it becomes perceptible. From the diffuse it becomes concentrated. From the indefinite it becomes definite. From the homogeneous it becomes heterogeneous. From the unstable it approaches the stable condition. Segregation, which is the selective process, is more marked in the organic than in the inorganic aggregate. Its parts are differentiated and rendered distinct and definite, while, through an increasing dependence between them, the whole aggregate becomes more and more firmly integrated or consolidated. Growth, which is increase of bulk, is simply the absorption of diffuse gaseous or liquid materials, which may theoretically be regarded as having originally belonged to the aggregate in its most widely diffused condition. Development, which is increase of structure, is the same process which all aggregates undergo in their transition from the homogeneous and indefinite toward the heterogeneous and definite, under the laws of segregation and the multiplication of effects. Finally, equilibration in organic aggregates is distinct and universal.

Every organism must reach this stage, and that in a comparatively brief period—so brief as to be capable of repeated

and easy observation. So plain does this stage of its progress become that it is feared that the predication of a stage of equilibration, not to say dissolution, for inorganic aggregates, is an argument from analogy, where the analogy is taken from a very subordinate class of phenomena, viz., from the observed equilibration of organic aggregates. A universal conclusion is deduced from a particular case; the law of the whole is assumed from that of a part. This, according to Mr. Spencer's own showing in his "Principles of Psychology," is the weakest form of reasoning. It should be admitted, however, that while the doctrine of the ultimate disintegration and dissolution of the celestial bodies rests on very insufficient inductive evidence, there are strong *a priori* grounds, beyond the domain of science, but clearly within the range of philosophy, which make it a legitimate object for the exercise of the "constructive imagination."

The most important truth which can be called in to aid us in this difficulty and apparent confusion of phenomena is that of the perpetual competitive operation of the forces both of evolution and of dissolution. Both these influences are at all times and in all kinds of aggregates simultaneously at work. The history of every aggregate is that of its struggle with these opposite contending influences. The final equilibration implies this. It is the establishment of equilibrium between just these forces. In the evolution of a star the forces of dissolution are mostly within the aggregate. In that of a star-system they seem to be wholly so.

678 The process of evolution goes on against | the inherent tendencies to dissolution. The equilibrium reached is between the attractive or integrating and the repulsive or disintegrating forces. Both are at all times active, and, if the latter at last prevail and the mode of redistribution is reversed, the gravitative influence still continues to oppose its progress. In an organism the disintegrating tendencies are chiefly from without. Everywhere on the globe the sun's influence is tending to prevent the integra-

tion of the liquid and gaseous elements. Life is the product of this struggle.

It may be laid down, as a universal law of the redistribution of matter, that organization is the product of the antagonistic tendencies of attraction and repulsion during the period in which the former prevails. Organization is, then, the great distinguishing characteristic of the process of evolution. The organization of the solar system is the result of this competitive struggle between these two agencies. It is the same with an organism. We have, then, at last reached a plane of generalization in which the cosmical and the organic processes may be regarded as parallel and homologous throughout. The active principle which directly results in organization is that which Mr. Spencer denominates *segregation*, by which the like parts are brought together and unlike parts separated.

The final result of this process is the formation of many distinct and definite parts which are unlike one another—heterogeneous. Each of these definite parts, differing from all the rest in the same aggregate, is, within itself, homogeneous, i. e., consists of a uniform internal structure. The like particles, in consequence of the similarity of their properties, naturally gravitate to the same place. In the case of the earth the atmosphere or gaseous portion forms a uniform envelope around it, due clearly to the nature and homogeneity of its molecular constitution. The waters, for the same reason, form a partial second envelope within this. The hardened crust of solid matter comes next, and in like manner the entire organization of the earth might be explained. Exactly the same process takes place in a living organism. Its various organs, vessels, specialized tissues, and differentiated parts, are the result of this same law of mechanical selection. The difference in the properties of the matter of each is at once the cause of their segregation and of their organic function.

The point at which we have arrived, therefore, is this: Organization is the necessary consequence of the com-

petition of the integrating and disintegrating forces, so long as the former prevail. The influence of the sun upon the matter of the globe is toward its disintegration and dissipation into gas. But for the opposing influence of gravitation, attraction, or concentration, this result would be speedily accomplished. But the resultant of these two antagonistic forces, at a time when their relative power is substantially what it now is on the surface of our globe, is such as to render possible the form of evolution which we
679 denominate organic life. A certain amount of the | matter of the globe is in the gaseous form. The gases themselves are differentiated into what we call oxygen, nitrogen, carbonic acid, and aqueous vapor, each of which exerts its special influence in the economy of vital existence, and without any one form of which, so far as we can see, life would be impossible. Another portion of the matter composing the earth exists in the liquid state, the chief form of which is water, of which more than half the weight of all organized beings consists. Evidently without water nothing answering to our conception of life could exist. Of the solid matter of the globe there exists the greatest heterogeneity, and it may be classified in a variety of different ways. Many, though probably by no means all, of the so-called distinct substances known to us are of direct value in the formation of organic tissues, and certain of them are clearly indispensable, so far as we understand their office; as, for example, lime, phosphorus, iron, etc., etc. Certain of these substances are crystalline, others colloid in their structure, the latter of which possess peculiar adaptations to the formation of organic tissue. Finally, between the solid and the liquid state there exist all grades of transition, thus adding variety to the organic adaptations.

As the universal law of concentration or integration proceeds to reduce all these varied forms to one, and to cement all in a single homogeneous solid, it is met by the powerful but somewhat irregular and erratic force of the solar radiations, reënforcing the inherent cosmical influences

already so far overcome in the evolution of the planet as to have brought it to its given state. The result of this conflict of forces is the condition in which we find our globe. Without the aid of the sun's rays, organic evolution might have been impossible. Without the aid of the cosmical force of concentration, in a certain way counteracting without neutralizing them, it would have equally been impossible. With such a predominance of the one as has probably prevailed in the past, or of the other as will probably prevail in the future, the particular form of evolution required to develop what we know as life seems also beyond the range of scientific probability. A few degrees more either of heat or of cold are sufficient utterly to destroy it. Of the latter, we have a near approach to a positive example in the state of things existing in regions round the poles of the earth's axis. Of the former, artificial proofs are easy, and certain desert regions of the globe constitute partial illustrations, easily completed by the imagination.

We thus learn what a precarious thing life is, within what narrow limits it is circumscribed, upon what slender conditions its possibility depends; contemplating which, we may be appalled to reflect how small a portion of the concentrated matter of space must be presumed to fall under these conditions. For, even if every world in space passes through this organic period, its duration must be ephemeral compared with the vast cycle of its existence.

| The important truth that it has been sought to reach by these considerations is, that organic evolution is but one of the minor manifestations of universal evolution. It occurs at a stage of the process when the struggle between the contending forces is very great, if not at its greatest. It is the immediate product of that struggle, and cannot exist when either the one or the other greatly predominates. The force to which we universally ascribe all possibility of life is the force which is tending to disintegrate the matter of the globe by absorbing the motion of the sun. The force which con- 680

stitutes evolution proper is that which bears down all life and reduces the face of Nature to a desert waste. The interaction of these two forces, where they are suitably proportioned, effects the organization of portions of the matter on the globe, and organization itself is life. The period of greatest organic perfection on a planet is therefore very different from the period of its greatest cosmical perfection, which corresponds with that of complete equilibration. Cosmical evolution is the history of the universe, organic evolution is a transient episode in the life of a paltry planet. We can only console ourselves with the belief that, but for this trifling digression of Nature, no being would have existed capable of formulating the laws of the universe.

Organic evolution must not, however, be restricted to the mere span which the life of an individual represents. To fully comprehend its scope, the conception of the organic aggregate should be extended to embrace all the life, past, present, and future, on the globe. The mysterious process of reproduction, unknown to all other aggregates, has the effect of binding all living organisms into one continuous whole, and giving to all terrestrial life the stamp of unity. The individuals of a race or species do not represent so many distinct aggregates. The qualities of antecedent forms, whether inherited or acquired, are transmitted to subsequent forms, thus conserving, as it were, all the organization previously evolved. Although the dissolution of the individual aggregate takes place, the work of evolution which has been going on within it is passed on to a new generation, to be there continued and again transmitted. The individual, therefore, becomes of comparatively small importance. The real organic aggregate is the race. The race alone is capable of receiving and preserving all the products of organic evolution. Ontogenetic development is lost sight of in the march of phylogenetic development. The individual is merged in the species, the species in the genus, the order, the class, and all are finally swallowed up

in the *tout ensemble* of organized existence. Organic being, as such, is the final term to which the generalization must be carried before the true scope of organic evolution can be adequately grasped by the mind. Individuals perish and are decomposed; species become extinct; genera, families, and whole classes, are swept from the earth. The broadest divisions into which the organic kingdoms of Nature have been classified have each their | periods of ascend- 681
ancy and decline. But organic evolution ever continues. Progress in organization is the constant result. It is always, on the whole, the less organized that gives way to the more organized. If the rich and exuberant cryptogamic vegetation of the Carboniferous epoch has dwindled away into the insignificant cryptogamic vegetation of our time, it has been succeeded by a phanerogamic vegetation of far higher organization and nobler qualities. If the great saurian dynasty that ruled the Cretaceous age has surrendered its sceptre and disappeared from the stage of terrestrial life, a far higher mammalian dynasty, at whose head man now stands, has taken up that sceptre and is moving on to still loftier heights of organic development.

We have thus arrived at the highest point from which the phenomena of organic evolution can be surveyed. What do we see? We see that, in proportion as our point of view rises, the relative importance of the phenomena of dissolution to those of evolution diminishes. We see that the dissolution of the individual aggregate affects but little the evolution of the race-aggregate, and not at all that of the complete life-aggregate of the globe. We see that, amid all the evanescent forms that surround us, the evolution of life is constant; that of organic being as such there is no dissolution. We thus find the parallelism between cosmic and organic evolution, which at the outset seemed so paradoxical, and afterward so imperfect, to be at last complete. In the one as in the other, the only phenomena which we know to be universal are those of evolution. In the one as

in the other, the opposite class of phemonena are wholly subordinate, special, and local. In the one as in the other, the forces of attraction and repulsion, of integration and disintegration, are in perpetual conflict. In the one as in the other, the organization of matter is the result. Just as the doctrine of the ultimate dissolution of the bodies of space rests on *a priori* deductions alone, unsupported by empirical observation, so must the final disorganization of the life of our globe be inferred from cosmological principles, which transcend the present limits of astronomy and physics. So far as we are capable of penetrating the mysteries of space or of life, we find that evolution is the law of the universe; while the forces which oppose that law, though powerful and ever active, are secondary and subordinate, and only seem to reverse it by the destruction of transient forms. In the genesis of world-systems this counter-evolutionary force consists in the inherent expansive power of diffused matter, or, what amounts to the same thing, in the resistance which such matter offers to the forces of condensation. In the phenomena of life this resistance comes chiefly from the sun, whose thermal radiations tend to dissipate the elements of the globe.

We are thus brought into full view of the deepest truth that underlies the redistribution of matter—the profound
682 antithesis be|tween *gravitation* and *ethereal vibration*, which constitute, in the last analysis, the true correlative *principles* of which evolution and dissolution are the corresponding *processes*. These are the agencies which are at all times antagonizing each other in all parts of the universe, and whose exact equality in it seems to form a logical tenet of the modern cosmology. A certain golden mean between these forces, but in which the former must predominate, results in organization; star-systems are formed in space, and life is developed out of the planetary elements. Such appears to be the state of all the matter within the range of human observation. For, whatever may be the condition of other worlds or other regions of space, the phenomena of

our world and our portion of space belong to the ascending series; and whatever may be the final doom of our planet and our universe, both are now in a state of progress, and are still rejoicing in the morning of creation.

90. The Province of Statistics

History.—Written October 15–26, 1877. See the next article.

The National Union, Washington, D. C., Daily issue, Vol. I, No. 22, October 27, 1877, second page.

THE report on internal commerce by Mr. Joseph Nimmo, Jr., of the U. S. Bureau of Statistics, is at once a valuable and suggestive document. It is valuable for the number and importance of the facts which it contains, and it is suggestive in indicating how much more could and should be done in the same direction. It shows that for our internal commerce, which more than a hundred times exceeds our foreign commerce, Government has thus far provided no means of systematically ascertaining its nature or extent, while for many years stringent laws have existed for the compulsory rendition of statistical returns of foreign commerce. It also shows that while this is one of the least objectionable modes of State interference with private enterprise, it is at the same time one of the most fruitful in its results and most easy of enforcement. It is, in truth, the initial step of all State regulation; for how can a State regulate abuses until it shall have first determined by statistics the exact nature of such abuses?

Another fact brought out by this report is, that the com-

pulsory rendition of statistical returns, so far from being a hardship upon private enterprise, is no more than strict justice to it. For if our free institutions are to be worth anything, they must be extended to all alike. To allow corporations to conceal the workings of their systems is equivalent to class legislation, and leads to great waste of wealth through the failures of those honestly seeking to embark in like enterprises. It thus deprives private enterprise of its chief claim to protection, viz., that competition in it is sufficient to keep prices and rates down, and tends to establish unlimited monopoly.

These considerations should suffice to direct the attention of our legislators to the nature of statistics in general, and the true office which they are capable of performing in the national polity.

We are fond of declaring that we live in an age of practical science, and we rightly point with exultation to the mighty revolution which has been wrought in every department of industrial life by the application of scientific principles and physical laws to the means of supplying the wants of society. But in its ultimate analysis what is practical science but the adoption of the *statistical method* and its application to ever-present natural phenomena? The statistical method and the scientific method are one and the same thing. Natural phenomena had been always before men's eyes before the dawn of the scientific era, but they went unobserved and unrecorded. So far as noticed at all they were regarded as so many isolated facts, and as such were valueless. Men preferred in those days to sit down, close their eyes, and endeavor to evolve the laws of nature from their inner consciousness. Such attempts proved fruitless, and not until the method of carefully observing and systematically recording the phenomena of nature had been fully recognized and rigidly applied did any success attend their efforts to ascertain the *laws* of nature. But this is precisely the statistical method. It is the continued application of this method to which civilization is indebted for all the grand

applications of steam, electricity and the other so-called civilizing forces. Not only internal commerce but foreign commerce as well would have been scarcely worth reporting but for that prolonged statistical labor by which their present greatness has been made possible. It is now fully recognized that the essence of all science, and that which distinguishes it from mere empiricism, is statistics, a truth easily illustrated by examples from astronomy, physics, chemistry, or any other of the sciences.

All these grand results in practical science have been made possible because the laws of nature are uniform. Wherever the statistical method has been applied it has fully established this uniformity. It is only in recent times that this method has been applied to the phenomena of society—to the facts of the industrial and commercial world; and, although the name of statistics is usually given to this application of it only, it should not be forgotten that it is simply the old inductive method of Bacon and of Newton turned to a new field of facts. But even in this new field the statistical method has demonstrated the universal prevalence of uniform laws. Whether you record the facts of production, of transportation, of exchange, of finance, of labor, of religion, politics, government—everywhere you find law, regularity, uniformity. Even the trivial mistakes of defective memory, haste, &c., as Buckle has proved, occur with surprising regularity—a fact attested by the statistics of Dead Letter offices. Why not, then, apply the statistical method to government, to legislation? The truth is, government is to-day where manufactures and intercommunication were before the scientific epoch, and for the same reason; because it has thus far failed to apply the statistical, the scientific method, to national affairs. And when government once comes to adopt this method with all the faith and zeal with which science adopted it, may we not hope to see some such a revival in the domain of national law as was inaugurated then in the domain of physical law?

The instrument for the accomplishment of this object already exists, at least in embryo, in the United States Bureau of Statistics, but for several years past the disposition of Congress has been to cripple this bureau and to restrict rather than enlarge the scope of its operations. Its possible utility to the nation can hardly be over-estimated, but to produce the results of which it is capable, it must be adequately supported by a Congress qualified to appreciate its true functions and to place a proper estimate upon the value of statistical work.

91. The Way to Scientific Lawmaking

History.—This article and the last were outlined on October 15, 1877, and the final draft written on the 26th. It was intended as an article on the United States Bureau of Statistics, its operations and usefulness. I had been employed in that Bureau since 1867. Mr. Edward T. Peters was also at that time an employee of the Bureau, but he was writing the editorial matter for the *National Union*. We were intimate friends and I submitted the article to him. He divided it and gave to the parts the titles which they bear. He feared that some sentences in the second part might be objected to by Dr. Edward Young, then Chief of the Bureau, and by common consent these were stricken out. To adapt the second part to the new title he wrote the first two paragraphs. The remainder is as I wrote it. This second part was republished in the Weekly issue of the *National Union*.

Ibid., No. 28, November 3, 1877, second page; Weekly issue, Vol. I, No. 2, November 8, 1877, page 44.

IN a recent article on the province of statistics we showed that to social science statistical facts have the same relation which the observations of investigators bear to physics, and we pointed out the necessity of increased

attention to such facts and increased effort in their collection and classification as a means of securing for sociology some share in that splendid progress by which the physical sciences have been distinguished since the Baconian method of investigation and study began to be applied to them.

The science which deals with humanity, and a proper understanding of which would lead to a vast amelioration in the condition of the human race, is surely as worthy of public encouragement as any of those which deal with the laws that govern inert matter; and there are special reasons why more than any of the less complicated sciences it is in need of active public assistance. Such assistance can only be adequately rendered through the direct agency of government, since it must consist mainly in the collection of statistics, which can only be obtained in obedience to governmental authority. Something is already done in this direction by our own Government and by a number of the States, but nothing in comparison with what the importance of the subject would warrant. No appropriations made by Congress have been made more grudgingly than those for the National Bureau of Statistics, and yet none of them are applied to work in the results of which that body is so directly interested.

The primary object of statistics should be to influence and direct legislation. The facts of statistics point out the laws of trade and of all other movements in society. The true function of legislation is to remove all obstructions from these social movements and to cause their free operation to effect the least possible injury to public and private interests. In order to legislate to this end these natural laws must be understood. They can only be understood by the study of the facts which they present, i. e., of statistics. Every movement of whatever nature going on in the country should be regularly reported to a central office, and all such facts should be there systematically elaborated and published in tables, charts, dia-

grams, &c., and regularly laid before Congress for its use in framing laws for the benefit of the general public.

The director of this central office or bureau should have charge of all branches of statistics. He could thus directly compare the operations of different movements and coordinate all the facts found to possess a common bond. The phenomena relating to different kinds of production should be frequently placed in juxtaposition with a view to showing which branches should be stimulated and which checked. For while agricultural production cannot, perhaps, ever be too great, manufactures frequently far exceed the needs of the country before the fact is made known by the operation of natural laws.

Again the phenomena of production should be constantly compared with those of transportation and exchange, and statistics of all these branches of industry would suffice to indicate what legislation is necessary to harmonize the workings of them all.

In like manner financial statistics would show the condition of capital in the country and suggest the requisite legislation to bring it into its proper relations with labor. Vital and sanitary statistics should be compared with those of industry for a similar purpose. Statistics of immigration and emigration as well as of internal migration so far as obtainable should be given a prominent place. Indeed, the taking of the census, which is preëminently a statistical work, should be placed under the Bureau of Statistics, where uniformity and method could be made to replace our past irregular and chaotic mode of taking the census. The Bureau of Statistics would thus become, as it should be, a large and influential bureau. It should take a high rank among the bureaus of the Government and the highest talent should be secured not only to direct it but also to fill the subordinate positions in it. Finally, a liberal policy should be pursued towards the Bureau of Statistics, and especially should it be exempted from those sudden changes which sometimes affect certain branches of the Govern-

ment, caused by great and abrupt reductions in the force and change of *personnel*. Such cataclysms would here more than anywhere else tend to destroy the accumulated labor and thought of years, and to overthrow useful systems of valuable records, whose chief value consists in the length of time they have been made and the regularity of method with which they have been recorded. We are informed that a Bureau of Statistics was created in 1845, and that for several years important statistical reports were made and published, embracing mining statistics, bank statistics, &c. But this bureau soon fell a prey to mistaken "retrenchment," or to some other of the unfortunate vicissitudes to which representative governments are unhappily subject, and the memory of it had well nigh been blotted out. But suppose this bureau had been permitted to stand and to grow with the natural growth of the nation under a liberal patronage of Congress and the management of competent officers, who can estimate the value of such a bureau to-day and that of the uninterrupted series of recorded facts of vital national import that would have accumulated?

92. [Remarks on Texas]

History.—Made February 11, 1878. Abstract written out February 12th. Having elaborated the Texas collection (see infra, No. 96), I decided to lay the results before the Potomac Side Naturalists' Club, which I did at the meeting on February 11th, and added some comments on the excursion. It then occurred to me to put an item about it in the paper, and the next day I wrote it out. I think Mr. Peters was present at the meeting and suggested that I do so and hand it to him for publication in the *National Union*, of which he was Managing Editor. I find a statement that I left the notes on his table on the 12th, he being absent. But he must have found them, as they appeared in the issue of the 15th.

Ibid., Daily issue, No. 115, February 15, 1878, third page.

AT the last regular monthly meeting of the Potomac Side Naturalists' Club, held at the Franklin School Building, Mr. Lester F. Ward gave an account of the extensive excursion through Texas, which was made by twenty-seven members of the American Association for the

Advancement of Science in September last, of which he was the botanist. He had completed the elaboration of his collection and reported 330 species, of which 87 were not found east of the Mississippi.

In addition to the more technical scientific report, Mr. Ward took occasion to express his views of Texas as it had impressed him after over two weeks of almost constant travel over the chief railroad lines of the State. The excursion visited Fort Worth, Austin, San Antonio and Galveston, or all the most western and southern railroad termini of the great State, and thus enjoyed as good opportunities as the time would afford to become acquainted with its resources. From an agricultural point of view the State of Texas, so far as visited by the party, is unsurpassed by any other portion of the country. Comparing it with the prairie region of Illinois, Iowa, and Nebraska, with the great plains of Colorado and Wyoming, and with the great basin of Utah and Nevada, Mr. Ward did not hesitate to pronounce it superior to any of these, as not possessing the two great drawbacks—scarcity of timber and scarcity of rain; while its small fertile prairies give it all the advantages of a prairie country. In fact, eastern and central Texas is a thoroughly *inhabitable* region, whose real merits have not as yet been sufficiently appreciated.

93. On the Genealogy of Plants

History.—From almost the beginning of my botanical operations in 1872 I had been convinced that the so-called "natural system" of botany was wrong and practically a reversal of the order of plant development. As early as 1876 I began to sketch a paper on "The Natural System of Plants." I finished this rough sketch on January 17, 1877, but laid it aside until I should have read Julius Sachs's *Lehrbuch der Botanik*, which I imported in the fall of 1876, and very slowly and carefully read, devoting an entire year to it. I then rewrote my paper, December 17, 1877, to February 2, 1878. On the latter date I read it in part before the Philosophical Society of Washington, and completed the reading on the 16th. The paper was too long for a single article, and I divided it into two, calling the first the *Genealogy of Plants*, and the second the *Natural Succession of the Dicotyledons*. I wrote them both anew, the first March 28 to April 10, 1878, and the second June 28 to July 9, 1878, and published them in the *American Naturalist*.

The American Naturalist, Philadelphia, Vol. XII, No. 6, June, 1878, pp. 359–378.

ONE of the most remarkable anomalies which the history of science and that of the human mind afford, is to be found in the appreciation which has been shown of the relationships which the different forms of life present. There has been no lack of acumen in discerning these relationships, in detecting the differences or recognizing the affinities, but there has been frequent failure to comprehend their meaning. The term relationship has been employed in a sort of metaphorical or metaphysical sense, as denoting mere resemblance wholly disconnected from any idea of natural dependence; as if the objects of nature were arbitrarily grouped into classes, orders, and genera by the operation of some law of "preëstablished harmony." It might be supposed that the term relationship, constantly in use in this sense, ought to have suggested the analogy to family, or *consanguineal* relationship among men, and led naturalists to seek to account for the resemblances observed among plants and animals on some such principle as that on which family resemblances are explained. Yet this simple deduction proved too profound for the human mind, and botanists and zoölogists went on accumulating facts down to the time of Lamarck, and most of them to that of Darwin, without perceiving their most obvious meaning. And there are still many who fail to perceive it, and who openly reject it when pointed out to them.

It is perhaps but proper to add that this state of things has not been wholly due to an inability to make rational deductions, but has been in part brought about by the existence of preconceived ideas, which were sufficient to preclude all attempts to reason towards the true conclusion, however plain this course might appear to the unbiased mind.

But now that it is becoming generally recognized that the

present forms of life are the true descendants of antecedent forms, and that the observed resemblances are the physical result of real or genetic relationship identical with that which makes children resemble their parents, it is but natural that old systems of classification should require to be entirely recast and molded into harmony with this fundamental truth. Such, indeed, is the case, and already
360 marked progress has been made, especially in zoölogy, in which department chiefly, nearly all the most advanced workers in this field have concentrated their efforts.

In addition to other and greater benefits, this revolution has had the effect to relieve the systematists of the odium which naturally attaches to the apparently useless labor of classifying objects conceived as independent of one another. A dependence once established, classification becomes a vital process, and the only means of solving the highest of all scientific questions, that of the genesis of organic beings. Every fact in morphology or physiology, hitherto regarded too much as ends in themselves, now becomes an additional link in the chain of evidence which is to establish the genealogical history of a plant or an animal. Thus classification, formerly regarded as simply a means for the more convenient study of living things, becomes the highest object and chief end of biological investigation.

It is a matter of common remark that in the sudden advance of biological science which has taken place during the last eighteen years, it has been left for botany to bring up the rear. Prior to 1859 it was generally conceded that the science of plants occupied a considerably more advanced position than that of animals. This was due in the main to the impetus which it received at the hands of the Jussieus, who, following up the labors of Tournefort, had given to botany its so-called "Natural System."

But the Jussieus understood relationship only in the metaphorical sense, and maintained the fixity of species, and the system they established could not of course satisfy, in all respects, the law of genealogical descent. Its worst

vice was the weighty authority which it acquired, and which became a serious barrier to its extension and rectification. But there are other reasons, existing in the nature of the two departments of biology, and which need not here be stated, that have contributed to permit our study of the vegetable kingdom to be outstripped by that of the animal kingdom. There has not, however, been wanting a deep sense of the inadequacy of the so-called Natural System of Plants, and in quite recent times its imperfections have become too obtrusive to be longer disregarded, even though greatly reduced by the labors of Lindley, de Candolle, Hooker, Gray and others; and an effort has already been commenced, especially on the Continent, to subject that system to a thorough criticism, with the aid of the new light which the modern school of biology has kindled in all its departments.

| I do not propose in this paper either to review the literature of this subject, which is already becoming voluminous, or to attempt, among the many conflicting theories advanced, to reconstruct the natural system, but shall seek rather, in the light of both the new facts and the new principles already accepted, to state some of the objections to the received classification, and sketch, in its most general outlines, the form and direction which I conceive that the approaching reform is most likely to assume. 361

Probably the most objectionable feature of the system of classification proposed by Jussieu and still adhered to in nearly every systematic work on botany, is the position of the Gymnosperms. These constitute a sub-class of the Exogens and are made coördinate with the sub-class Angiosperms, which only embraces the Dicotyledons proper, or true flowering Exogens.

This arrangement and terminology involve a number of grave inconsistencies. In the first place the so-called Endogens, or monocotyledonous plants, are as truly Angiosperms as are the plants to which that term has been thus specially applied, the pistil consisting in both cases of a

closed ovary. The Gymnosperms, therefore, in the present system are placed between the two great divisions of the Angiosperms and made to interrupt the natural series. The most casual observation, of both the foliage and the flowers, shows how awkward this position is, and indicates without closer scrutiny, that the Gymnosperms are out of place. Moreover, the enclosure of the germ is what chiefly distinguishes the phanerogamic from the cryptogamic series, and the degree to which this is accomplished should mark the degree of advancement from the cryptogamic state. But we shall presently look deeper into this phase of the question.

In the second place, the reason assigned for the position of the Gymnosperms is the exogenous structure of their woody tissue. This argument might have some force if the *Coniferæ* only were embraced in the sub-class; but when we consider the *Cycadaceæ*, which equally belong there, a difficulty arises. Here the woody tissue assimilates almost altogether that of the endogenous palms or cryptogamic tree-ferns.

Again, the wood of the *Coniferæ* is by no means identical with that of the true Dicotyledons. It is destitute of the continuous vessels called ducts with their minutely porous joints, so characteristic of the former. The secondary wood
362 consists, with the | exception of the medullary rays, entirely of large tubes, called *tracheïdes*, occupied with large prosenchymatous cells, which latter are nearly of uniform shape, while in the true Dicotyledons the tissue is in part parenchymous and the cells much more numerous and varied in form; moreover, the small circular areas enclosed between the walls of adjacent cells or *tracheïdes* are much more numerous and pronounced, especially in old tissue, in the *Coniferæ* than in the Exogens proper.

There is still a third important respect in which the Gymnosperms differ from the remaining Exogens in a marked manner. This is in the number of cotyledons, which is here usually more than two, and sometimes as

many as fifteen, while in true dicotyledonous plants the number is uniformly two; only a very few exceptions having ever yet been found; as, for example, in *Ranunculus ficaria*, which usually has but one, and in some species of *Phaseolus*, which sometimes have a whorl of three.

The objections above enumerated to the position of the *Gymnospermæ* in the prevailing system are quite independent of any recent facts pointing to their origin and derivation, and would be equally applicable under the old metaphorical conception of relationship. It is, therefore, all the more strange that it should have survived so long and should have required the argument from descent to finally break it down.

Evidence of this nature, however, is not now wanting, and it very plainly points to the direct *filiation* of the Gymnosperms upon the Cryptogams. This evidence concerns two important sets of characters, the woody tissue and the reproductive organs. As regards the former the close resemblance of the *Cycadaceæ* to the arborescent ferns is very obvious from a glance at a cross section of each. If this character, therefore, possessed the importance which is claimed for it, it would be found more difficult to pass from the *Cycadaceæ* to the *Coniferæ* than from the latter to the Dicotyledons. And we shall hereafter see that great liberty has been taken in thus grouping the *Cycadaceæ* and *Coniferæ* together.

If we consider the *Coniferæ* alone there is one class of facts recently brought to light which possesses an unusual interest. The investigations of Prof. Williamson [1] have shown that the trunks of *Lepidodendron*, exhumed from the coal beds of England, | exhibit a species of exogenous growth. This differs not only from that of the existing pines and from that of the true Exogens, but also from that now known to take place in certain monocotyledonous plants, and constitutes a sort of fourth type. 363

[1] *On the Organization of the Fossil Plants of the Coal Measures.* Phil. Trans., 1872.

It consists, so far as understood, in the formation of a layer of growing tissue with dividing cells(*meristem*) around each fibro-vascular bundle, the continuous division of whose cells necessitates a radial or centrifugal increase of the entire stem. A similar structure on a small scale occurs in certain now living cryptogamic forms, as in *Botrychium*, *Isoëtes*, etc. This form of exogenous growth may perhaps be regarded as marking a transition from the endogenous structure of most cryptogamic stems to the form of exogenous structure which prevails in the *Coniferæ*, but which has not been transmitted to the branch from which, on the hypothesis of descent, the *Cycadaceæ* have been developed.

The transition in the reproductive system is far more obvious and remarkable. What is known as "alternate generation," so long familiar to zoölogists, is now found to prevail throughout the greater part of the vegetable kingdom. It is most apparent in the higher Cryptogams, especially in the mosses, ferns, *Equisetaceæ* and *Lycopodiaceæ*. In all these the final stage is the production of a plant or "generation" capable of developing spores, which are of both sexes, and produce the sexual plant. Among the vascular Cryptogams there are two orders, one the *Rhizocarpeæ* in the fern group, the other the *Ligulatæ* in the club-moss group, in which the final spore-bearing stage is sexually differentiated. These produce two kinds of spores, called respectively, from their relative size, *macrospores* and *microspores*, the former of which develops a female, and the latter a male *prothallium*, or sexual plant. This *prothallium*, which in most vascular Cryptogams is an object of considerable size, and which corresponds to the entire leafy portion of the mosses, liverworts, and other cellular forms, continues to diminish as the degree of organization increases; the spore-bearing generation, on the contrary, increasing in a corresponding ratio; the large fronds of a fern representing only the seta and capsule, or fruiting portion of a moss. In the *Rhizocarpeæ* and *Ligulatæ*, whose macrospores and microspores indicate a higher

organization, this reduction of the sexual generation is carried so far that the *prothallium* scarcely protrudes from the spore, or is wholly confined within it. Hoffmeister[2] has long ago pointed out the true significance of these facts, and shown that we have only to continue 364
this same process a step beyond what it has already reached in *Salvinia* and *Isoëtes* to arrive at the condition presented by the existing Gymnosperms, the *Cycadaceæ* and *Coniferæ*. Here the macrospore exists under the name of embryo-sac, while the microspores are the pollen-grains. The so-called *macrosporangia* of these highest Cryptogams thus correspond to the ovules[3] of the Phanerogams, while the anther-cells of these latter are homologous with the *microsporangia* of the former. The *prothallium* is readily traced to the Gymnosperms, especially in the fertile flowers, where it reappears under the name *endosperm*, and constitutes the albumen or reserve material of the future seed—one of the finest examples in biology of the fundamental identity of the reproductive and nutritive functions. In the staminate flowers the *prothallium* may be considered as represented by the *pollen-tube* (the elongated cell that descends from the pollen grains into the ovary and fertilizes the germ), although a careful study of the microspores of *Isoëtes*, in which one cell remains sterile while the rest develop the *spermatozoids*, may leave some doubt as to whether the homology is here quite complete. The greatest differentiation has gone on in the macrospores; the microspores and the plants and organs bearing them, still presenting, in many cases, a striking resemblance. In the *Cycadaceæ*, for example, the anther-cells are sessile and single or in groups upon the lower surface of the broad filaments, like the "fruit dots" on the back of a fern. In the *Coniferæ* the stamens

[2] *Vergleichende Untersuchungen*, 1851.

[3] Sachs (*Lehrbuch der Botanik*, 4 Aufl. S. 481) justly objects to the term ovule (or little egg) as entirely misleading in its etymology, and as tending to perpetuate the error that gave rise to its use, and proposes the term seed-bud (Samenknospe) as a substitute.

are less leaf-like, but the pollen-sacs are often solitary and scattered over the under surface of the flattened filaments.

An interesting similarity also exists between the male aments of certain *Taxaceæ*, as in the yew and the juniper, and the spikes of *Equisetum*, the horse-tail or scouring-rush. In these cases it is said that nearly all the morphological homologies are satisfied.

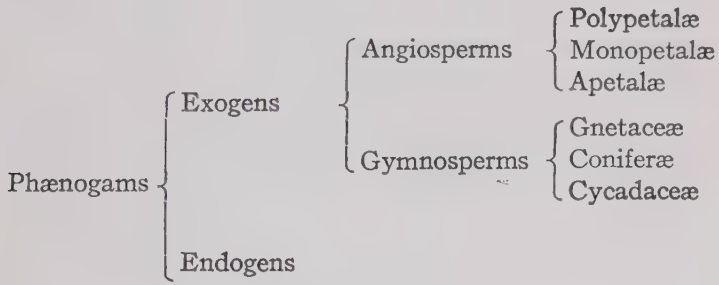
In general it may be said that in all these respects the *Cycadaceæ* resemble most the group of true ferns, the *Coniferæ* proper (pines, firs, etc.), most the club-moss group (Dichotomes), and the | *Taxaceæ*, most the *Equise-*
365 *taceæ;* a fact of great importance for the genealogy of plants, and to which we shall have occasion to refer again.

Upon the whole, therefore, it seems to be no longer open to serious doubt that both of these widely dissimilar orders of the *Gymnospermæ* (*Coniferæ* and *Cycadaceæ*), as also probably the *Gnetaceæ*, have been directly developed out of lower forms of cryptogamic vegetation. They should, therefore, certainly occupy a position at the base of the phænogamic series. Whatever may be ultimately accepted as the mode of transition from the Gymnosperms to the Angiosperms, it seems to be established that the former have actually descended from the latter, and they should therefore be all assigned a higher place in the scale of organization.

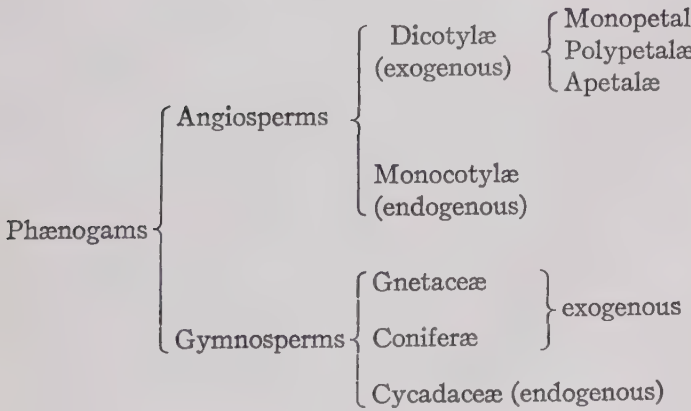
It is one of the misfortunes of botanical science that above the cellular plants no classification based on histological structure can be made; so nearly identical are the forms of structure through which all classes of vegetation pass. It is therefore necessary to depend in the main upon differences of the reproductive system, as affording the best characters by means of which to trace the development of vegetable forms. The Gymnosperms, no less than the Angiosperms, have both classes of structure, and we may almost say the same for the Cryptogams. But from the Cryptogam to the Gymnosperm, and from this to the Angiosperm, there is a continuous advance in one direction

toward the complete protection of the germ as it is accomplished by the perfect ovary. It is indispensable, therefore, that all plants possessing this important character should be erected into one great group or class, and that from this group all plants to which this character does not belong be rigidly excluded. The terms *endogenous* and *exogenous* being common to both Angiosperms and Gymnosperms, should be excluded from the classification, or only employed to mark the subordinate divisions. The two systems of classification for the phænogamic series may therefore be thus compared:

366 OLD SYSTEM.



NEW SYSTEM.



The terms *Monocotylæ* and *Dicotylæ* are preferable to *Endogen* and *Exogen*, for the Angiosperms, since they lead to no confusion with the class *Gymnospermæ*. In this classification the terms conform to the strict rules for definition, each being wholly exclusive of all the rest. The reason for transposing the *Polypetalæ* and *Monopetalæ* will be given in another paper.

Before proceeding to consider more especially the manner in which the Angiosperms may have been derived from the Gymnosperms, it will be necessary to glance once more at the nature of the cryptogamic vegetation from which we suppose the latter to have descended. And for our purpose we may conveniently divide it into three groups: 1st, the group of true ferns; 2nd, the | group of the club-
367 mosses; and 3rd, the horsetail group, or *Equisetaceæ*. The first of these groups seems to have come down to us from the Carboniferous epoch almost in an unchanged condition, trunks of tree-ferns quite similar to those still found growing in tropical countries having been exhumed from the coal measures. The second group must be made to embrace the ancient *Lepidodendron*, which flourished so abundantly in that luxuriant age, and whose resemblance to both our club-mosses and to the proper Conifers has been so frequently remarked. In this group, therefore, there must have been great degeneracy, as of it the forests of that period seem to have been chiefly composed, while nothing now remains but the low herbaceous and moss-like plants that form our *Lycopodiaceæ*.[4] To the third group belonged the famous Calamites of the coal beds, and these too have dwindled into insignificant rushes.

Such is in fact the fundamental division of the cryptogamic series, and it is based as well upon differences of internal constitution as of external aspect. If we associate these three classes of Cryptogams, respectively, with the

[4] In the Sunda Islands there is a Lycopod that attains a diameter of six inches and a height of twenty-five feet.

three orders of the Gymnosperms, *Cycadaceæ*, *Coniferæ*, and *Gnetaceæ*, we shall be able to discern many remarkable resemblances, which, while they may really signify nothing, are sufficient at least to suggest an hypothesis. In the first group, or that of the true ferns, we have in the existing *Rhizocarpeæ*, to which our *Azolla* belongs, and of which the genera *Salvinia*, *Marsilea*, and *Pilularia* have been carefully studied, an undoubted transition towards the general condition presented by the *Cycadaceæ*. It is not unfavorable to this theory of transition that the existing forms indicating it are small and humble plants. The slight differentiation of the sexless spore into the macrospore and microspore could of itself have scarcely given the new form a special hold upon its environment, and we may almost wonder that this intermediary stage should not have succumbed altogether, as all the later ones probably have done. But the true phænogamic or flowering state once reached, permanence was acquired, and with it the power of attaining a higher development. It is remarkable that this differentiation affected the reproductive system only, and has left the woody tissue and also the foliage of the fern and the Cycad to a great extent unchanged.

| That the *Coniferæ* proper (*Abietineæ*) have descended from the second or club-moss group, seems 368
even better established than that the Cycads have sprung from the ferns.

The affinities of the extinct *Lepidodendron* with this group have always been recognized. Those who claim for *Lepidodendron* a Coniferous character only strengthen this view by showing how closely the two groups approached each other in those ancient times. The Araucarian pine of the southern hemisphere is even now covered with scales over its entire surface, and presents no small analogy with the *Lycopodiaceæ* and with what is known to have been the character of *Lepidodendron*. We must, therefore, regard *Araucaria* as our nearest living representative of the early transition form through which the Pine family was derived

from the Carboniferous Lepidophytes. And it is especially interesting to remark that it is just this Araucarian group of true Conifers which we find associated with the arborescent cryptogamic vegetation, and whose scaly trunks lie side by side with the equally scaly trunks of *Lepidodendron* in the coal formation—a fact which shows at how early a period the differentiation began, and how little progress has been made within the same group during subsequent geologic ages.

With regard to the great advance which must have been made in passing from the cryptogamic to the gymnospermous reproductive system, the evidence has already been briefly referred to. To the *Rhizocarpeæ* in the fern group correspond the *Ligulatæ* in the club-moss group, in which the asexual spore is completely differentiated into the sexual macrospore and microspore. In this order the only two genera thus far known, *Isoëtes* and *Selaginella*, have been faithfully studied by the foremost botanists of Europe, and the facts repeatedly verified. Hoffmeister's generalization, which is of the highest importance and has been generally accepted, has already been adduced, and its direct bearing on the immediate question need scarcely be reaffirmed.

The origin of the *Gnetaceæ* is far more obscure, and indeed so few positive facts have been brought forward to establish it that all speculation may be pronounced idle. That there is considerable general resemblance between the genus *Ephedra* and certain branching species of *Equisetum*, cannot be denied, but this similarity of habit is not accompanied by any corresponding similarity of structure either in the
369 tissue or in the fruiting apparatus, while | the few genera which have been grouped under this order vary enormously in everything but their mode of inflorescence. Whether they have been developed independently from the Cryptogams or have been off-shoots from lower Gymnosperms must therefore remain one of the problems of botanical science; but it is a problem, as we

shall presently see, which derives its great importance from the special *rôle* which the *Gnetaceæ* have been made to play, as a connecting link between the Gymnosperms and the Dicotyledons.

The highest marks of organization in the vegetable kingdom are the exogenous structure and the encasement of the germ. These may be regarded as the two great ends towards which vegetal life is perpetually striving. One of these ends is attained by the *Monocotylæ* or endogenous Angiosperms; both of them have been secured in the *Dicotylæ* or exogenous Angiosperms.

Although most of the intermediate stages, from the naked-seeded Cycad to the closed ovary of the Monocotyledon, have been obliterated, or have not been discovered, the evidence is nevertheless abundant that such a transition has taken place. If we consider what may be called their *physiognomy* alone, the descent of the true palm from the sago-palm, or both from a common ancestor in the *Cycadaceæ* would seem in a high degree probable. The great divergence in the matter of floral envelopes may be accounted for on the supposition that the differentiation, as is known to be frequently the case, was chiefly confined to the reproductive system and only slightly affected other characters. The absence of intermediate stages in our existing flora could then be explained by the now well-understood law of the ephemeral nature of transition forms. In fact the Cycad is itself a transition form connecting the Cryptogams with the true flowering plants, or Angiosperms, and as such it is doubtless a comparatively ephemeral state. So far as general aspect, or physiognomy, is concerned, the ordinary observer, without trained scientific insight, naturally and instinctively classes the palm, the sago-palm, and the tree-fern in one and the same group, little imagining that botanists class them each in such a widely different group. Language itself builds on so obvious a resemblance. What we call the sago-palm, connecting it with the higher type, the Germans call the palm-fern (*Palmfarn*), connecting it with

both the higher and lower types of vegetation. Should
370 further study | of these forms, in the light of the broadest principles of classification, lead the technical botanist to a recognition of their genetic relationship, and thus bridge over the two great chasms in the vegetable series, it would not be the first time that vulgar observation has been found to accord with true science after a long period of unmerited disdain.

The fact that the leaves of the *Cycadaceæ* grow from a terminal bud like the palms, while they unfold from the circinate apex like the ferns, shows that this resemblance to both palms and ferns is not altogether fanciful or purely superficial; in fact their genetic development from the latter, as already shown, is established by other evidence of the most vital character based on the morphology of the reproductive organs. It is therefore probable that the *Cycadaceæ* are not only more nearly related to both the *Palmaceæ* and the *Filices* than is generally supposed, but that they are less nearly related to the *Coniferæ* than is implied by their position in the received system of classification.

The wood of the *Cycadaceæ*, as already stated, consists of a mass of sheathed fibres in a large central pith composed chiefly of large prosenchymatous cells, and if not identical with that of the palms and arborescent ferns, certainly resembles this far more closely than it does that of the exogenous Gymnosperms. The similarity in the mode of flowering, without which such a position could never have been thought of, may perhaps have been accidental, the two widely divergent lines of vegetation passing through some of the same transition stages in their progress towards the ideal type of vegetal perfection. The evidence already adduced of the derivation of the *Coniferæ* from a distinct stock of Cryptogams, to which the *Lepidodendron* belonged, would seem to corroborate this view, and this quite independently of the real origin of the *Dicotylæ*. Nor should botanists despair of still finding plain traces, in the

transformations of the floral organs, of the descent of the *Monocotylæ* from the *Cycadaceæ*, and with this view the embryological study of the *Palmaceæ* cannot be too strongly urged.

The proper origin of the *Dicotylæ*, notwithstanding their possession of a closed ovary in common with the *Monocotylæ*, is a problem which presents the gravest difficulties to the genealogical systematist. Their derivation from the latter, though not wholly without legitimate evidence, is far from established, and may have to be altogether abandoned. The facts which support this hypothesis may be thus briefly summed up:

| The endogenous structure of monocotyledonous stems is of two classes. In the palms, as in the *Cycadaceæ* and arborescent ferns, the foliage springs from one terminal bud which attains its full development before expansion, after which no further lateral enlargement of the stem takes place. This may be regarded as the normal form of endogenous growth. But another form is found in the trunks of the arborescent *Liliaceæ*, as in *Dracæna*, *Yucca*, *Aloë*, etc., which may be regarded as representing an advance in the direction of an exogenous structure. The stems of these tree-like *Liliaceæ* actually undergo increase in size, or radial growth, after emerging from the bud. This takes place by the formation of a growing tissue (*meristem*) within the outer bark at certain distances below the terminal bud, which increases in thickness for some time before passing into permanent tissue, and effects an enlargement of the stem on all sides. A cross section of one of these trunks reveals a number of rings of this modified tissue, some of which are far internal, though at the time of their formation they must have formed the inner bark of the tree. 371

Although this is clearly an advance towards the true exogenous structure, it seems to be rather by way of analogy than of direct progress, the same end (power of strengthening the trunk to resist the force of gravity and of the

elements and thus to render greater size and longevity possible) being attained, but by the adoption of a somewhat different means.

There is another group of plants, wholly different from those just described, which also afford considerable evidence of forming a transition stage from the endogenous to the exogenous structure. These are the aquatic plants. Sanio observes that in *Potamogeton* and other aquatic and submerged Endogens, "an axial bundle extends continuously through the stem, the bundles from the leaves only subsequently uniting with it," "a condition," says Sachs, "quite anomalous in monocotyledonous plants, but also found in dicotyledonous water plants, particularly in the *Nymphæaceæ*." Such a condition found among aquatic plants is certainly very interesting in view of the probable aquatic character of all primordial vegetation, but whether these facts possess any real significance in connection with the question of the origin of the Dicotyledons still remains doubtful.

In the venation of leaves of monocotyledonous plants, which is usually parallel, there are to be observed
372 marked approaches | towards the reticulated structure which prevails with the *Dicotylæ*. Every one is familiar with many cases of this kind, as in *Dioscorea*, *Goodyera*, etc., while on the other hand, approaches to the parallel venation sometimes occur in the *Dicotylæ* (*Plantago*, etc.).

A far greater difficulty is presented by the cotyledons; for while there are a few cases in which exogenous plants develop but a single cotyledon, I am aware of no case in which an endogenous Angiosperm has been found to develop more than one. It is, however, presumable that a more complete investigation of this question may reveal transition forms here as elsewhere.

Such are the principal facts thus far made known which tend to encourage the hope of ever tracing the higher class of Angiosperms back to an origin within the lower class.

Far more satisfactory is the evidence that the Dicotyledons have been developed out of the *Gnetaceæ* and perhaps indirectly out of the *Coniferæ*. The *Gnetaceæ*, a small but interesting family of only three known genera (*Gnetum*, *Ephedra*, and *Welwitschia*) possess all the marks of forming a true intermediate link. The flowers of both sexes are provided with a sort of half-envelope, called the *perigonium*, which surrounds and protects the anther-bearing filament in the male, and the solitary ovule in the female flower, and may be regarded either as a rudimentary ovary or as a rudimentary perianth.

It is worth remarking here that the chasm between the Gymnosperms and Angiosperms is at all points greater with respect to the floral envelopes (including the ovarian) than with respect to the process and true organs of fertilization. The ovary of the Angiosperm is enclosed in an envelope, in the true Gymnosperm it exists but is exposed, in the *Gnetaceæ* it is half enclosed and half exposed. It matters not whether the *perigonium* be regarded as the homologue of the ovarian envelope or of the outer floral envelopes of the Angiosperms, since all the floral organs, including even the essential ones (stamens, pistils, etc.) are simply modified leaves. In the passage from the *Cycadaceæ* to the *Palmaceæ* no such connecting link has yet been discovered, and for the truth of such a transition we must rely upon the remarkably strong physiognomic resemblance coupled with the evidence furnished by the structure of the tissues and the mode of æstivation. The *Gnetaceæ*, however, while they give us this invincible evi|dence of a transition in the rudimentary ovary, would seem at 373 first view to afford no physiognomic mark to indicate the point at which the chasm was bridged over. There is one family of Dicotyledons, however, which, though little familiar to the inhabitants of the northern hemisphere, are none the less likely to have completed this transition, and in which there certainly is a strong physiognomic resemblance to at least one genus of the *Gnetaceæ*. Hum-

boldt,[5] speaking of the remarkable form of the *Casuarineæ* of the East Indies, describes them as "trees with equisetum-like branches" and remarks that "Plumier's *Equisetum altissimum*, and Forskal's *Ephedra aphylla* of North Africa, are forms nearly allied to *Casuarina*." This physiognomic resemblance of *Ephedra* to both *Casuarina* and *Equisetum* is certainly very interesting, not only as affording a provisional hypothesis for explaining the transition from the Gymnosperms to the *Dicotylæ*, but also as marking out a line of investigation with a view to determining the origin of the *Gnetaceæ*. But to this we shall revert.

Not only do the *Gnetaceæ* thus approach the *Dicotylæ* in their reproductive system, but they also present a corresponding advance in the formation of the secondary wood from the structure of the *Coniferæ* towards that of the true *Exogens*. Besides the *tracheïdes* of the former, it also contains vessels closely resembling the porous ducts of the latter.

Should the descent of the *Dicotylæ* from the *Gnetaceæ* be accepted as probable, it would only remain to determine the origin of the latter in order to complete a rough outline of the entire genealogy of vascular plants.

As already remarked, the attempt to affiliate them upon the *Equisetaceæ*, as a third independent branch of the Cryptogams, cannot be seriously made in the present state of science, notwithstanding the singular harmony in the general aspect of *Ephedra* and *Equisetum*. The fact heretofore pointed out, however, that a striking analogy subsists between the spikes of *Equisetum* and the male aments of *Taxus* and other allied genera, may be taken as a faint indication of what may have been the mode of development of these forms. It should at least be remarked that within the *Coniferæ* there is exhibited no small degree of progress towards certain leading characteristics possessed by the Dicotyledons. From the lowest to the highest, | from
374 the Araucarian pines to the yew trees, such progress

[5] *Ansichten der Natur*, Stuttgart, 1871, p. 187.

is well marked, and in *Salisburya*, the Japanese Ginkgo, which is related to the yew, the foliage comes at length closely to resemble that of many exogenous Angiosperms. The suspicion has even been expressed that all the genera of the *Coniferæ* may not have sprung from the same parent stock.

The origin of the *Dicotylæ*, which constitutes the chief problem in the genealogy of plants, is thus seen to be one which, while it admits of several possible solutions, nevertheless, in the present state of science, certainly admits of no positive solution. Whatever hypothesis we adopt, if we suppose a *monophyletic* origin for all plants, the derivation of both branches of the *Angiospermæ* from this common root will involve what may be thought to be a violent assumption. If the endogenous Angiosperms have developed out of the *Cycadaceæ* and the exogenous Angiosperms out of the *Gnetaceæ*, it requires some stretch of our credulity, in view of the bad repute into which all alleged "analogous" organs have in recent times fallen, to admit that the closed ovary, so identical in the two classes of plants, could have been arrived at from two such independent sources. To avoid this difficulty, which no one knows better how to appreciate, Prof. Haeckel suggests the probability that the Angiosperms as a class were first developed from the *Gnetaceæ*, and that subsequently they subdivided into the monocotyledonous and the dicotyledonous branches.[6] But with due deference to so high an authority, it is submitted that this would involve a still more violent assumption, viz., that an endogenous structure was derived from an exogenous one. Besides, we fail to find a single fact, either in morphology or in palæontology, to support this hypothesis. Again, if we seek to trace the genealogy of the *Dicotylæ* back through the *Monocotylæ* to the *Cycadaceæ*, we are driven to the equally forbidden presumption that the exogenous structure of the *Dicotylæ* and of the *Coniferæ* and *Gnetaceæ* was independently reached.

[6] *Schöpfungsgeschichte*, Aufl. 5, Berlin, 1874, S. 430.

There is, therefore, no serial line by following which all these difficulties can be escaped.

Those to whom all these instances of so-called "teleology" present no serious obstacle, may even find satisfaction in the conception that not only are the *Coniferæ* descended from two different parent stocks and the *Gnetaceæ*
375 from still a third, but | that the *Dicotylæ* may themselves be of heterogeneous origin, part of them being descendants of the *Coniferæ*, part, of the *Gnetaceæ*, and part, of the *Monocotylæ*. Should it ever become generally believed that the *Dicotylæ* are of multiple origin, the interest, now so great, in the true arrangement of the families of this class of plants would be greatly increased, and more satisfactory answers to many puzzling questions might be expected.

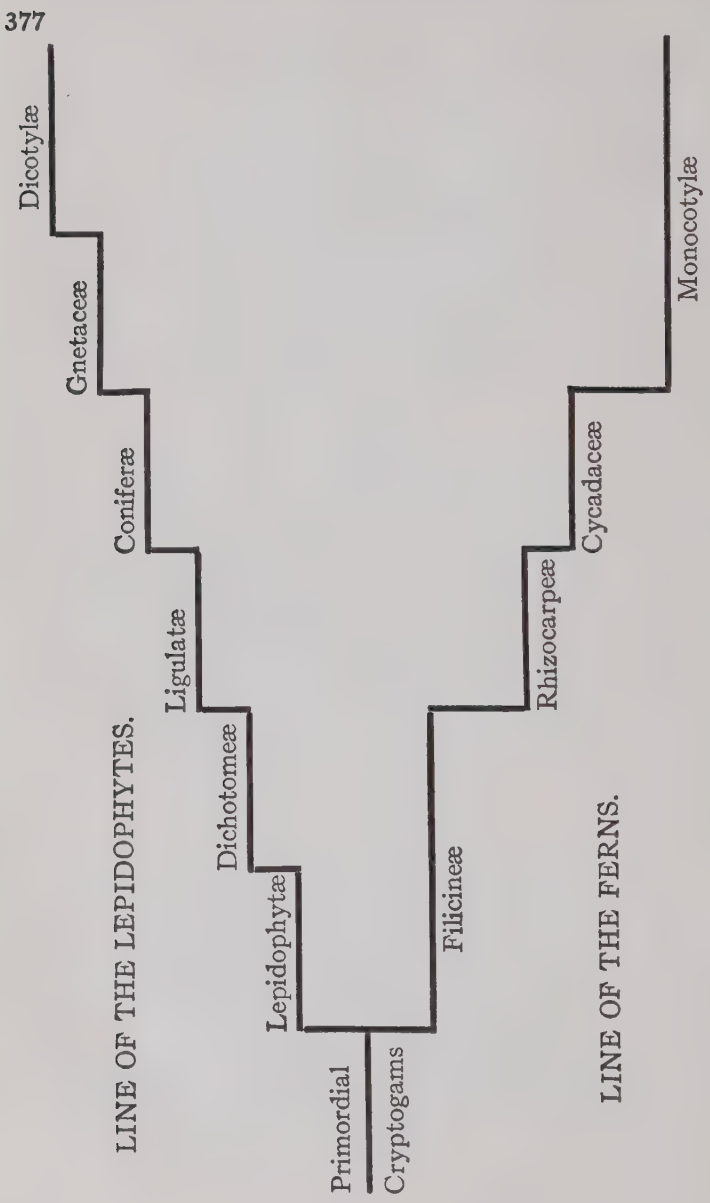
Perhaps the least objectionable of all the theories advanced, as that which requires the least extreme or improbable assumptions, and affords the greatest relief from the dilemma, is that which maintains the two great coördinate branches, or parallel ascending series of the vegetable kingdom, intact and independent from the most remote period to which they are traceable in the past history of the globe, and sees in the development of the endogenous and exogenous Angiosperms at the summit of each, respectively, the simple attainment in both of one of the great ends of vegetable existence, without which the highest functions of plant life cannot be manifested.

If we believe in the evolution of organic forms at all, we must accept that of vegetable forms, and if we are convinced that the higher plants are the descendants of lower ones, we ought by this time to have at least some provisional hypothesis as to the way in which this process of evolution has been going on in the vegetable world. We should not go on accumulating facts forever without attempting to make any use of them. In this age, when the law of descent has reached, in zoölogy, its exact stage, the stage of prevision and prediction, it is certainly time that

some of the operations of this law were recognized and studied in the cognate kingdom of plants. The utmost that can be objected to any present attempt to trace the genealogy of plants, is, that the precise truth has not been reached, and those who are really competent to raise this objection must be competent to present a nearer approximation to the truth, which is the very service which science most needs. It is, therefore, with a full sense of the imperfection and inherent objectionableness of the scheme, and an entire willingness to see it superseded by one which shall better satisfy all the facts of science, that the one here rudely sketched is submitted. Stripped of all its complicating conditions and qualifications, many of which have been referred to and explained, this scheme of genealogy
376 | may be more clearly presented by means of the following rough diagram, in which not only are all additional coördinate branches left unrepresented, but the continuation of each stage beyond the point of divergence is, for the sake of perspicuity, removed, leaving the differentiations only to stand in naked outline. This diagram presents the two great lines of descent, that of the Lepidophytes, of which we have the fossil genus *Lepidodendron* in the Carboniferous, and that of the ferns, trunks of whose arborescent forms are also found in the same formation. The line of the *Equisetaceæ* is omitted, although it probably had an independent existence, and may yet be found to have a genetic connection with some of the higher types.

The order of succession here laid down is confirmed by what is known respecting the time at which each of the several groups first appeared in the geological history of the globe. The primary divergence must have taken place in the latter part of the Devonian age, since within this formation occur some remains of *Lepidodendron*, while fossil trunks both of this and of true tree-ferns are found throughout the Carboniferous strata. It was in this latter epoch that both the ferns and the Dichotomes or

DIAGRAM SHOWING THE SUPPOSED LINES OF GENEALOGICAL DESCENT OF VASCULAR PLANTS.



Lycopodites attained their greatest perfection and abundance. Whether any of the large trees belonging to either of these groups had advanced to the stage now represented by the *Ligulatæ* and *Rhizocarpeæ*, there is no means of knowing, but that this stage was reached in both the great lines during the Carboniferous epoch must follow from our hypothesis, since it is within this epoch that both the *Coniferæ* and the *Cycadaceæ* first made their appearance, and during which they attained to very much the proportions and general character which certain forms of them still present. These forms advanced at a parallel rate and both reached the point of greatest development and supremacy at about the same time in the Triassic and Jurassic periods. They are both at the present time clearly on the decline, especially the *Cycadaceæ*, which are on the open road to early extinction before the march of higher types of vegetation. The paleontology of the *Gnetaceæ* is little known, but they have been supposed to have originated in the later Permian, or in the Trias. They constitute at best but a transition form, and are not sufficiently abundant to be likely to be discovered in a fossil state. It is a remarkable
378 fact that the earliest remains of both the *Monocotylæ* and the *Dicotylæ* have been found | in the same formation, viz., the Chalk, and although their first actual appearance may date back into the Jura or Trias, it is probable that in point of time the two great classes of Angiosperms had a nearly simultaneous origin. Whether either of these great vegetable types has reached its highest destiny on the earth it is impossible with certainty to affirm, but the indications are that, for the *Dicotylæ* at least, progress in organization is still going on.

In order to complete the systematic survey of the vegetable kingdom from the point of view of genealogical descent, the following logical scheme of classification is appended for comparison with the genealogical scheme presented on the preceding page:

- Phænogams
  - Angiosperms
    - Dicotylæ (exogenous)
    - Monocotylæ (endogenous)
  - Gymnosperms
    - Gnetaceæ, Coniferæ (exogenous)
    - Cycadaceæ (endogenous)
- Cryptogams
  - Lepidophytæ
    - Dichotomeæ
      - Ligulatæ
      - Lycopodiaceæ
    - Equisetaceæ (?)
  - Filicineæ
    - Rhizocarpeæ
    - Filices

94. Polypodium vulgare on Trees

History.—The observation was made on March 17, 1878, on Rock Creek near the north corner of the District of Columbia. The note was probably written the same day. The beautiful effect of the gray or hoary polypody, growing so abundantly on the trunks of trees in the borders of the Dismal Swamp, had strongly impressed me, and since visiting that region I had been carefully watching the common polypody, so abundant on rocks in the vicinity of Washington, to see if it ever grew on trees. This was the only case I observed.

Field and Forest, Washington, D. C., Vol. III, No. 9, March, 1878, p. 150.

I HAVE found a birch tree (*Betula nigra*), with a large amount of *Polypodium vulgare* growing upon its trunk several feet above the base, after the manner of *P. incanum*. It is a clear case, as no more of the plant was to be seen in the vicinity and there were no rocks near by. The roots have taken a firm hold in the clean living bark, so that I collected my specimens with a knife leaving the bark attached. I would be glad to know whether this habit has been observed before.

95. Cross-fertilization in Sabbatia angularis

History.—The plants were collected and observations made on July 28, 1878, in the Rock Creek region, now within the Rock Creek Park, and the note was written on July 30–31, after a careful examination of the specimens, which I had placed in water so as not to be distorted by pressure. After the note appeared I received a letter from Dr. Asa Gray dated September 4, 1878, in which he says that what I describe is common to all the species of Sabbatia (*S. angularis* is the only one growing around Washington), and that he had called attention to it in a note to which he could not refer, in his book, *How Plants Grow*, and in his *Synoptical Flora of North America*. I looked up the two latter references, and found that they mentioned the styles only, and very incidentally, as "commonly turned to one side," whereas the most striking fact was that the stamens were turned to the opposite side as I described. In a later letter (September 14, 1878) Dr. Gray says that Mr. W. W. Bailey first called his attention to this form of dichogamy in Sabbatia, and adds

(very truly) that "the turning of the style to one side is common to several plants (*Clerodendron, Epilobium angustifolium*, etc.)." But he now goes on to say: "In *Sabbatia* the opposite position of the stamens is quite new to me. Have you any sketches? Can you send me fresh pressed flowers to show it?" I sent him specimens at once, and received a note dated September 22d, in which he says: "We had not noticed this in the stamens of *S. chloroides*, nor in *S. stellaris*—seen alive some years ago. I shall have occasion to refer to it in the new edition of *Structural Botany*, now preparing." Accordingly we find on pages 221–222 of the *Structural Botany* the following remark: "In *Sabbatia angularis*, Lester F. Ward (here referring to this paper in a foot-note) observed that the anthers of freshly opened blossoms are all thrown to one side almost as strongly as the style is thrown in the opposite direction."

On February 22, 1879, I sent Dr. Gray seeds of *Sabbatia angularis*, but I never heard what use he made of them. During the season of 1879 I made further studies of the phenomenon, and on August 1st, I figured several specimens. Then I prepared another paper on the subject which I read at the meeting of Section B (Natural History) of the American Association for the Advancement of Science at Saratoga on September 1st. The title was: "Note on the Movement of the Stamens of *Sabbatia angularis*." This paper was not published, but the title appears in the Proceedings, Vol. XXVIII, page 488.

The Gardener's Monthly and Horticulturist, Philadelphia, Vol. XX, No. 237, September, 1878, p. 278.

THIS handsome flower, which is quite common in the vicinity of Washington, and which blooms about the end of July, presents a device for the prevention of self-fertilization, which has not, it is believed, been met with in any other species of plant, and so far as I am aware, has not yet been described.

The flower has five stamens with elongated, introrse anthers, which are abruptly curved outward near the summit, and a single style about the length of the stamens terminated by a forked stigmatic portion nearly as much longer. These branches of the style which are stigmatic on the inside are at first closely twisted together in such a manner as to conceal the stigmatic surfaces. Later they untwist and present a simply bifurcate appearance, but this does not take place until the anthers have shed most of their pollen, by which the advantages of dichogamy are in a measure secured, the pollen of the later flowers being conveyed by insects to the stigmas of earlier ones. But in addition to this, the style is in all cases found to be abruptly bent at the base, so as to form an angle of from forty-five to ninety degrees with the perpendicular, carrying the stigmas entirely away from the stamens, and usually locating them between the lobes of the corolla. And, as if this were not enough, the stamens also are found in a great majority of cases to be bent in the opposite direction, so as to lean more or less conspicuously away from the center, while in many of the flowers the filaments lie flat down upon the floral envelopes, the style at the same time occupying a horizontal position on the other side. At a later stage, and after fertilization has been effected, both the stamens and the style partially or completely regain the erect position.

96. Texas Plants

History.—This paper is mine only in the sense that I collected and identified the plants and corrected the proofs of the list. I sent a full set of the plants, duly labeled and systematically arranged, to Mr. Phippen for any use he might make of them. He prepared a list of them and presented his set of the plants to the Essex Institute, of which he was Curator of Botany, and read a paper to the Institute at its regular meeting on April 15, 1878, on "Impressions of the Flora of Texas." The paper was published in the Bulletin of that date, and to it the list was appended. He then proceeded to publish the list separately in pamphlet form at his own expense. There was considerable correspondence and many changes were made. The pamphlet appeared in October, 1878, and on the 28th of that month I received from him 100 copies. He had generously given me the whole credit for it, and modestly omitted his own name entirely. I desired to send out the list to my botanical correspondents, having duplicates of the plants to exchange with them, but I was

unwilling to do so without some acknowledgment of Mr. Phippen's part in the work. I therefore took my 100 copies to a printer and had such an acknowledgment printed on the fly-leaf of each copy. I sent one copy, thus improved, to Mr. Phippen, but for some time he failed to notice what I had done. He ultimately discovered it, however, and was very grateful.

TEXAS PLANTS | COLLECTED BY | LESTER F. WARD, | WASHINGTON, D. C., | 1877.

An especial acknowledgment is due to Mr. Geo. D. Phippen, Curator of Botany for the Essex Institute, Salem, Mass., for his kind co-operation. He accompanied the excursion and rendered constant and efficient aid in the collection and preparation of the specimens; and since his return, without solicitation, and at his own expense, has generously edited and published this Catalogue.

LESTER F. WARD.

LIST OF PLANTS collected chiefly in Texas, by LESTER F. WARD, while on an excursion of the members of the AMERICAN ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE, after the adjournment of the Nashville meeting in 1877. Route, via Chattanooga, Memphis, across Arkansas, through Texas and return, over most of the railroad lines of that great state.

Those marked thus (*) are not in Mann's Catalogue, and are chiefly trans-Mississippi species. The twelve marked thus (†) are Lookout Mountain plants, collected by an assistant.[1]

1. Clematis reticulata, Walt.
2. Magnolia grandiflora, L.
3. Cocculus Carolinus, DC.
4. Nelumbium luteum, Willd.
5. *Argemone Mexicana*, L.
6. Nasturtium sessiliflorum, Nutt.
7. Arabis hesperidoides, Gray.
8. *Cleome pungens*, Willd.
9. Ascyrum Crux-Andreæ, L.
10. " stans, Michx.

[1] The "assistant" was Mr. Phippen—L. F. W.

11. Hypericum angulosum, Michx.
12. " aureum, Bartram.
13.**Tamarix Gallica*, L.
14.†Silene stellata, Ait.
15. Anychia dichotoma, Michx.
16. Paronychia dichotoma, Nutt.
17.* " setacea, Gray.
18. Sesuvium Portulacastrum, L.
19.*Talinum parviflorum, Nutt.
20. Malvastrum angustum, Gray.
21.*Malvaviscus Drummondii, T.& G.
22.*Gossypium herbaceum, L.
23. Zanthoxylum Carolinianum, Lam.
24.*Rhus copallina, L.,
var. lanceolata, Gray.
25.*Vitis candicans, Eng.
26. " vulpina, L.
27. " indivisa, Willd.
28. " bipinnata, Torr. & Gray.
29. Frangula Caroliniana, Gray.
30.*Colubrina Texensis, Gray.
31. Sapindus marginatus, Willd.
32. Cardiospermum Halicacabum, L.
33. Polygala lutea, L.
34.*Psoralea linearifolia, T. & G.
35.*Eysenhardtia amorphoides, H. B. K.
36.*Petalostemon multiflorum, Nutt.
37. Amorpha fruticosa, L.
38. Indigofera leptosepala, Nutt.
39.*Daubentonia longifolia, DC.
40. Glottidium Floridanum, DC.
41. Stylosanthes elatior, Swartz.
42. Desmodium lævigatum, DC.
43. " paniculatum, DC.
44. " pauciflorum, DC.
45. " sessilifolium, T. & G.
46. " strictum, DC.
47. " viridiflorum, Beck.
48. Lespedeza procumbens, Michx.
49. " repens, Torr. & Gray.
50. " violacea, Pers.
51.† " Stuvei, Nutt.
52. " *striata*, Hook. & Arn.
53.† " hirta, Ell.
54.†Phaseolus diversifolius, Pers.
55. " helvolus, L.
56. Centrosema Virginianum, Benth.
57.*Sophora speciosa, Benth.
58.*Cercis occidentalis, Torr.
59. *Cassia occidentalis*, L.
60. " obtusifolia, L.
61.* " Roemeriana, Scheele.
62. " Chamæcrista, L.
63.† " nictitans, L.
64.*Parkinsonia acauleata, L.
65.*Prosopis glandulosa, Torr.
66.*Acacia Farnesiana, Willd.
67. Gleditschia triacanthos, L.
68. Mimosa strigillosa, Torr. & Gray.
69. Neptunia lutea, Benth.
70.*Prunus rivularis, Scheele.
71. Gillenia stipulacea, Nutt.
72.*Rosa foliolosa, Nutt.
73. Cratægus arborescens, Ell.
74. Hydrangea radiata, Walt.
75. Philadelphus hirsutus, Nutt.
76. Heuchera villosa, Michx.
77. Sedum pulchellum, Michx.
78. " Nevii, Gray.
79.*Gaura longiflora, Spach.
80.*Stenosiphon virgatus, Spach.
81. Œnothera sinuata, L.
82.* " Drummondii, Hook.
83. Jussiæa repens, L.
84.**Lagerstræmia Indica*, L.
85. Ammannia latifolia, L.
86.*Opuntia Comanchica, Eng.
87.**Papaya vulgaris*, DC.
88.†Passiflora incarnata, L.
89. Bryonia Boykinii, Torr. & Gray.
90. Hydrocotyle interrupta, Muhl.
91. Eryngium yuccæfolium, Michx.
92.* " Leavenworthii, T. & G.
93. Thaspium trifoliatum, Gray.
94.*Cornus Drummondii, C.A. Meyer.
95. Symphoricarpos vulgaris, Michx.
96. Viburnum prunifolium, L. var.
97. Spermacoce glabra, Michx.
98. Diodia Virginica, L.

99.**Gardenia florida*, L.
100. Houstonia purpurea, L.
101. Vernonia fasciculata, Michx., var. altissima, Torr. & Gray.
102. Vernonia angustifolia, Michx.
103.* " Lindheimeri, Eng. & Gr.
104. Elephantopus tomentosus, L.
105. Liatris elegans, Willd.
106. " scariosa, Willd.
107.* " mucronata, DC.
108. Kuhnia eupatorioides, L.
109. Eupatorium album, L.
110. " altissimum, L.
111.† " aromaticum, L.
112. " incarnatum, L.
113. " parviflorum, Ell.
114. " serotinum, Michx.
115. Aster cordifolius, L.
116. " divaricatus, Nutt.
117. " lævis, L.
118. " paludosus, Ait.
119. " patens, Ait.
120. Erigeron strigosum, Muhl.
121.* " scaposum, DC.
122.*Aphanostephus Arkansanus, Gray.
123.†Diplopappus cornifolius, Darl.
124. Boltonia diffusa, L'Her.
125.*Amphiachyris dracunculoides, DC.
126.*Gutierrezia Texana, T. & G.
127. Brachychæta cordata, T. & G.
128. Solidago gigantea, Ait.
129. " lanceolata, L.
130.* " leptocephala, T. & G.
131. " nemoralis, Ait.
132. " odora, Ait.
133. " petiolaris, Ait.
134. " Radula, Nutt.
135. " rigida, L.
136. " rupestris, Raf.
137. " serotina, Ait.
138. " speciosa, Nutt.
139.* " speciosa, Nutt., var. angusta, Gray.
140. " tortifolia, Ell.
141.† " ulmifolia, Muhl.
142.*Grindelia squarrosa, Dunal.
143.*Aplopappus phyllocephalus, DC.
144. Isopappus divaricatus, T. & G.
145. Heterotheca scabra, DC.
146. Chrysopsis graminifolia, Nutt.
147.† " Mariana, Nutt.
148.* " pilosa, Nutt.
149. Pluchea bifrons, DC.
150. " fœtida, DC.
151. " camphorata, DC.
152. Silphium compositum, Michx.
153. Berlandiera tomentosa, var. dealbata, T. & G.
154.*Melampodium cinereum, DC.
155. Parthenium Hysterophorus, L.
156. Iva frutescens, L.
157. " ciliata, Willd.
158. " microcephala, Nutt.
159. Ambrosia bidentata, Michx.
160. " psilostachya, DC.
161. Xanthium strumarium, L., var. echinatum, Gray.
162. Borrichia frutescens, DC.
163. Rudbeckia triloba, L.
164. " nitida, Nutt.
165. Lepachys pinnata, Torr. & Gray.
166.* " columnaris, Gray, var. pulcherrima, Don.
167. Helianthus angustifolius, L.
168. " doronicoides, Lam.
169. " microcephalus, T. & G.
170. " occidentalis, Riddell, var. plantaginifolius, T. & G.
171.*Helianthus Maximiliani, Schrad.
172.* " lenticularis, Dougl.
173. Coreopsis aristosa, Michx.
174. " senifolia, Michx., var. stellata, T. & G.
175.*Thelesperma subsimplicifolium, Gray.
176.*Thelesperma filifolium, Gray.
177. Spilanthes Nuttallii, T. & G.
178.*Ximenesia enceloides, Cav.
179. Verbesina Virginica, L.
180. Gaillardia lanceolata, Michx.

181.*Gaillardia pulchella, Foug.
182.*Palafoxia callosa, T. & G.
183. Helenium tenuifolium, Nutt.
184. " microcephalum, DC.
185. Leptopoda brachypoda, T. & G.
186. *Artemisia vulgaris*, L.
187. Gnaphalium polycephalum, Michx., var. angusta, Gray.
188.*Centaurea Americana, Nutt.
189. Hieracium Gronovii, L.
190. " venosum, L.
191. Lobelia cardinalis, L.
192. " puberula, Michx.
193. Campanula divaricata, Michx.
194. Epigæa repens, L.
195. Oxydendrum arboreum, DC.
196. Clethra alnifolia, L.
197. Ilex decidua, Walt.
198.*Diospyros Texana, Scheele.
199. Bumelia lanuginosa, Pers.
200. Statice Limonium, L., var. Caroliniana, Gr.
201. Samolus Valerandi, L., var. Americanus, Gray.
202. Martynia proboscidea, Glox.
203.*Penstemon Cobæa, Nutt.?
204. Conobea multifida, Benth.
205. Herpestis Monniera, H. B. K.
206. " nigrescens, Benth.
207. Gerardia purpurea, L.
208. " aspera, Dougl.
209. " quercifolia, Pursh.
210. " grandiflora, Benth.
211. Ruellia ciliosa, Pursh.
212. " strepens, L.
213.* " tuberosa, L.
214. Dicliptera brachiata, Spreng.
215. *Verbena officinalis*, L.
216. " bracteosa, Michx.
217. " Aubletia, L.
218.* " Lucæana, Walp.
219. Lippia nodiflora, Michx.
220. Callicarpa Americana, L.
221. Trichostema dichotomum, L.
222. Isanthus cæruleus, Michx.
223.*Pycnanthemum albescens, T. & G.
224.*Hedeoma Drummondii, Benth.
225.† " pulegioides, Pers.
226. Salvia azurea, Lam.
227.*Scutellaria Drummondii, Benth.
228. *Heliotropium Europæum*, L.
229. " Curassavicum, L.
230. " tenellum, Torr.
231. *Heliophytum Indicum*, DC.
232. Onosmodium molle, Michx.
233.*Hydrolea ovata, Nutt.
234. Phlox glaberrima, L.
235. Gilia coronopifolia, Pers.
236. Ipomœa commutata, R. & S.
237. Cuscuta inflexa, Engelm.
238.*Solanum Texanum, DC.
239.* " Elæagnifolium, Cav.
240.* " Lindheimerianum, Sch.
241.* " rostratum, Dunal.
242. Physalis angulata, L.
243. " Pennsylvanica, L., var. lanceolata, Gray.
244. *Nicandra physaloides*, Gærtn.
245. Lycium Carolinianum, Michx.
246. Sabbatia calycosa, Pursh.
247.*Eustoma Russellianum, Don.
248. Polypremum procumbens, L.
249. Spigelia Marilandica, L.
250.**Nerium Oleander*, L.
251.*Asclepias longicornu, Benth.
252.*Asclepiodora viridis, Gray.
253. Enslenia albida, Nutt.
254. Gonolobus lævis, Michx.
255.* " biflorus, Nutt.
256. Fraxinus Americana, L.
257. Forestiera ligustrina, Poir.
258. " acuminata, Poir.
259. Asarum arifolium, Michx.
260.*Mirabilis jalapa, L.
261.*Oxybaphus hirsutus, Sweet.
262.*Rivina lævis, L.
263. Atriplex arenaria, Nutt.
264. Salicornia mucronata, Big., var. suffrutescens, Watson.

265. *Amarantus albus*, L.
266. Montelia tamariscina, Gray.
267. Iresine celosioides, L.
268.*Alternanthera lanuginosa, Torr.
269. Polygonum aviclare, L.
270. " Pennsylvanicum, L.
271. " setaceum, Baldwin.
272. " tenue, Michx.
273. Eriogonum longifolium, Nutt.
274. Persea Carolinensis, Nees.
275.†Euphorbia corollata, L.
276. " dentata, Michx.
277. " glyptosperma, Engelm.
278. " marginata, Pursh.
279. " serpens, H. B. K.
280.* " zygophylloides, Boiss.
281.* " prostrata, Ait.
282. Stillingia slyvatica, L., var. linaricefolia, J. Müll.
283. Acalypha Virginica, L., var. gracilens, Gray.
284. Acalypha Caroliniana, Walt.
285. Tragia urticæfolia, Michx.
286. Croton maritimus, Walt.
287.* " muricatus, Nutt.
288. " glandulosus, L.
289. " capitatus, Michx.
290. " monanthogynus, Michx.
291.*Argyrothamnia humilis, J. Müll.
292.*Phyllanthus polygonoides, Spg.
293. Batis maritima, L.
294. Ulmus alata, Michx.
295.* " crassifolia, Nutt.
296.*Celtis pallida, Torr.
297. Parietaria Pennsylvanica, Muhl.
298. Juglans nigra, L.
299. Carya tomentosa, Nutt.
300. Quercus aquatica, Catesby.
301. " macrocarpa, Michx.
302. " palustris, Du Roi.
303. " Prinus, L.
304. " Prinus, L. var. acuminata, Michx.
305. Castanea pumila, Michx.
306. Populus monilifera, Ait.
307. Populus angulata, Ait.
308. Pinus Taeda, L.
309. Taxodium distichum, Richard.
310. Juniperus Virginiana, L.
311.* " occidentalis, Hook., var. conjungens, Eng.
312. Lemna minor, L.
313. Spiranthes simplex, Gray.
314.*Cooperia Drummondii, Herb.
315. Agave Virginica, L.
316. Tillandsia recurvata, Pursh.
317. " usneoides, L.
318. Sisyrinchium Bermudiana, L.
319. Smilax tamnoides, L.
320. " Pseudo-China, L.
321. Allium striatum, Jacq.
322.*Yucca rupicola, Scheele.
323. Commelyna Virginica, L.
324. Cyperus diandrus, Torr.
325. " filiculmis, Vahl.
326. " inflexus, Muhl.
327. " microdontus, Torr.
328. " rotundus, L., var. Hydra, Gray.
329. " strigosus, L.
330.* " litos, Schult.
331. Kyllingia pumila, Michx.
332. Fimbristylis capillaris, Gray.
333. Rhynchospora inexpansa, Vahl.
334. Carex verrucosa, Ell.
335. Vilfa aspera, Beauv.
336. " vaginæflora, Torr.
337. " Virginica, Beauv.
338. Sporobolus Indicus, Brown.
339. Muhlenbergia capillaris, Kunth.
340. Aristida purpurascens, Poir.
341.* " purpurea, Nutt.
342. Spartina gracilis, Hook.
343.*Buchlcē dactyloides, Eng.
344. Bouteloua hirsuta, Lagasca.
345. " curtipendula, Gray.
346. Gymnopogon racemosus, Beauv.
347.*Chloris verticillata, Nutt.
348. *Cynodon Dactylon*, Pers.
349. Leptochloa mucronata, Kunth.

350. Tricuspis ambigua, Chapm.
351.* " albescens, Munro.
352. Brizopyrum spicatum, Hook.
353. Eragrostis Frankii, Meyer.
354. " Purshii, Schrad.
355.* " pilifera, Scheele.
356.* " interrupta, Nutt.
357.* " capitata, Nutt.
358.* " oxylepis, Torr.
359. Paspalum læve, Michx.
360. Panicum obtusum, H. B. K.
361.*Panicum Crus-galli*, L.
362. Cenchrus tribuloides, L.
363. Andropogon furcatus, Muhl.
364. " scoparius, Michx.
365. " argenteus, Ell.
366. Sorghum nutans, Gray.
367.*Sorghum vulgare*, L.
368. Monanthochloë littoralis, Engelm.
369. Pellæa atropurpurea, Link.
370. Woodsia obtusa, Torrey.

97. On the Natural Succession of the Dicotyledons[1]

History.—See the history of the paper "On the Genealogy of Plants" (*supra*, p. 174). This was rewritten in its present form June 28 to July 9, 1878.

The American Naturalist, Philadelphia, Vol. XII, No. 11, November, 1878, pp. 724–734.

THE system of classification for dicotyledonous plants now in use in most text books of botany is substantially that of Antoine Laurent de Jussieu, as published in his *Genera Plantarum* in 1789. Although many minor modifications have been made and are still being made by different authors, the fundamental arrangement into three "Divisions," depending on the nature of
725 the corolla, has been maintained in its integrity to the present | day; only two serious attempts having yet been made to cut loose from it, one of which has failed to command an acceptance, notwithstanding the eminence of its author, while the other is still too new to

[1] A sequel to the article "On the Genealogy of Plants" in the June number. The substance of the two articles was embodied in a
724 paper read before the Philosophical Society of Washington, February 16, 1878.

permit an opinion as to its ultimate success. I refer to Dr. Lindley's classification as elaborated in his *Vegetable Kingdom*, and to the system proposed by Sachs in his *Text Book of Botany*.

In the first,[1] or, as it is supposed, highest of the three "Divisions," the corolla consists of distinct pieces or *petals* not at all connected with each other, and this is called the Polypetalous Division. In the second group these petals are united, at least at their base, the distinct divisions only appearing, if at all, in the form of a "limb" of separate lobes at the summit of a tube of greater or less length. This group is called the Monopetalous Division. The third group wants the petals and corolla entirely, the perianth consisting of a single envelope which is always assumed to be the outer or calyx. Plants of this nature form the Apetalous Division; they are also frequently denominated monochlamydeous, those of the other two divisions being designated as dichlamydeous.

The defects of this classification have long been apparent, and although so persistently adhered to, it has always been a source of trouble to systematists, no two ever entirely agreeing as to its precise limits. Even those who wholly ignore or reject the doctrine of descent seek to bring together as nearly as possible those plants which actually resemble each other most, since this is the fundamental idea, and formerly the only idea, of a "natural system." Yet in adhering to the principle involved in the classification by Divisions this was frequently impossible, the two principles being often in direct conflict. In every such case it is clear that the maintenance of the Divisions involved, is

[1] The propriety of commencing text books of Botany or Natural History with the highest or most perfectly organized families and descending the scale so as to end with the lowest or most imperfectly organized may well be questioned. Though doubtless more convenient for beginners to study, it tends to antagonize and keep out of view the truth of a progressive historical development in living things which, to the majority of students, is of greater value than any technical acquaintance with specialized forms.

so far, an *artificial*, as contradistinguished from a *natural* system of classification. And indeed it is difficult to see how a system of classification based on the corolla is more natural or less artificial than one based on the stamens. If it could be shown that this class of characters are
726 | more permanent or reliable, or that they are more comprehensive, and better typify the general sum of the characters distinguishing groups of plants, a point in their favor would be gained, but, as we shall see, such is not the case. In point of fact these characters frequently change when nothing else has changed, and often remain the same when everything else widely differs. They constantly tend to "run together," and no strict dividing line exists between them. They also frequently vary within very narrow groups, sometimes in the same species or individual. Critically viewed, therefore, this system so far as it goes, presents as many imperfections and stands as directly in the way of the adoption of a truly natural system as did the professedly artificial one of Linnæus.

The recognition of the three Divisions, as is made in nearly all systematic works on botany, even the most recent, involves numerous direct conflicts with the best established orders of dicotyledonous plants. Many orders are found to contain species and genera whose corollas would require them to be placed in a different Division from that in which the order itself has been placed. Examples of this class are abundant. *Paronychia*, a genus which seems clearly to belong to the polypetalous order *Caryophyllaceæ* (*Illecebreæ*), is usually apetalous, though some species retain a rudiment [2] of the petals in the form of

[2] The term "vestige" would probably be more correct. It is certainly remarkable that this term has not been more generally adopted to express this important distinction so clearly perceived by the naturalists of this epoch. The terms "rudiment" and "rudimentary" should be confined to those organs which the life-history of the plant or animal shows to be in process of development or formation. On the other hand, those organs which, from disuse or other causes, have dwindled into mere remnants of once perfect ones should be distinguished by the

minute teeth or bristles; *Chrysosplenium* in the order *Saxifragaceæ* is another example of the same class. *Glaux* in the monopetalous order *Primulaceæ* is destitute of a corolla. *Ludwigia*, *Ammannia*, *Penthorum*, *Nyssa*, are further illustrations, and only the most familiar need be mentioned. Most of the *Euphorbiaceæ* in this country (if we except *Euphorbia* itself), which are monœcious, have polypetalous staminate (male), and apetalous fertile (female) flowers. Here we have the two extreme Divisions united in the same individual plant (*Croton*, *Tragia*, etc.).
| Again, there are cases in which the lobes of the nominally gamopetalous corolla are so deeply parted that it becomes difficult to determine whether they are at all united, and in which the union sometimes actually ceases to exist. Of this class might be mentioned at random *Symplocos*, *Statice*, *Naumbergia*, *Anagallis*, *Chionanthus*, *Fraxinus*. The last named genus is of special interest in consequence of the close general resemblance between the ash and maple families, which are, however, widely separated in the present system. That beautiful climber, *Boussingaultia baselloides*, commonly known as the Madeira vine, is botanically related to the *Portulacaceæ*, but the petals are barely united at the base, for which reason it has been removed from its natural association and placed in the monopetalous division. 727

Thus we find that while some botanists have preferred to maintain well-established orders intact by allowing them to embrace genera and species whose corolla would require them to be placed in different Divisions, others have chosen rather to remove such anomalous genera to their appropriate Divisions, and if necessary to create new orders for

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term "vestiges" or an equally appropriate and expressive one. Yet these are the so-called "rudimentary organs" which have played so great a *rôle* in the modern theories of science, and Mr. Darwin himself employs this expression in that sense without commenting on its bad etymology.

them. Some, for example, leave *Paronychia*, *Anychia*, etc., in the *Caryophyllaceæ*, with which they are clearly allied, while others place them in the apetalous Division near the *Polygonaceæ*, with which they doubtless are also allied. But there are many cases which cannot be thus easily disposed of, as the *Aquifoliaceæ*, *Euphorbiaceæ*, *Asclepiadaceæ*, etc., in which cases the entire order is changed about from one Division to another, according as the author may think the preponderance of characters requires.

Not only does it frequently occur that an order which cannot be divided contains genera representing two of the general types of corolla upon which the Divisions are founded, but some orders, as the *Primulaceæ*, actually embrace all three of these types. In the order just named we find *Naumbergia*, which is frequently polypetalous, and *Glaux*, which is always apetalous, while most of the genera are monopetalous.

These few examples, which might easily be extended, certainly show that the so-called Divisions of the *Dicotylæ* do not form a natural series. They rather indicate that they represent three parallel and coördinate series, in any one of which orders closely corresponding may be named in one or both the others. Thus the *Caryophyllaceæ* may
728 be compared with the *Polygonaceæ*, the *Acen|ineæ* with the *Oleaceæ*, the *Aquifoliaceæ* with the *Rhamnaceæ*, the *Malvaceæ* with the *Euphorbiaceæ*, and the *Hamamelaceæ* with the *Platanaceæ*. These comparisons and others that will suggest themselves to every botanist, reveal natural relationships between plants which are far removed from each other because they fail to agree in the one character on which the Divisions are based. They clearly show, therefore, that the arrangement by Divisions is an artificial one, and that the fact of the coherence or non-coherence of the petals is far from a reliable one as indicating the true succession, much less the genealogical descent of the families.

It is not claimed, however, that the three mostly parallel series wholly fail to express any general law of the vegetable kingdom, and an attempt will be made before concluding the subject to show that they do express in a partial manner an important truth in phytonomy. Though concurrent for a great part of their length and inosculating all along, these lines of development appear not to have had simultaneous origin. But before entering upon the direct treatment of this problem it will be necessary to consider another class of facts.

The practice thus far dwelt upon of distorting the natural system by an undue regard for the corolla is only one example under a general class. The vice itself expressed in general terms, is that of adhering too closely to any one character to the neglect of all the rest. We thus find cases within the same Division in which orders unquestionably allied are not placed together, but are widely separated. Every one has been struck by the resemblance of certain Ranunculaceous with certain Rosaceous plants, especially as to foliage and general habit; for example, *Ranunculus* with *Geum*, *Actæa* with *Spiræa*, etc. It is customary with botanists to affect a certain degree of contempt for such general resemblances, and they are commonly regarded as wholly misleading. That they cannot be depended upon as safe guides to special investigation all will of course admit, since it so frequently happens that striking similarities exist between families which cannot in any way be assimilated. But even in such cases the resemblances often vanish on closer inspection and prove to have been produced by entirely dissimilar processes. General resemblances which will bear close inspection are rarely without a meaning. There is a certain correlation which subsists | among all the characters of a plant so that those which 729 have similar organs of reproduction usually exhibit strong family relationships. Were it not so familiar it would be a surprising fact that a Solanaceous plant can usually be detected as such without examining the flowers,

merely by a certain undefinable appearance which belongs to the family. The same is true to a greater or less extent with all the large orders, *Cruciferæ*, *Borraginaceæ*, *Urticaceæ*, etc. In some families still more subtle characteristics persist with great uniformity, of which the peculiar odor of the *Ordhidaceæ* is a good example.

This so-called "general aspect" is in reality the *ensemble* of all the characters which make a plant such as it is, and though any one character is as liable to vary as another or as more obvious ones, their number is so great that it requires an enormous period of time so to efface them all as to destroy all traces of resemblance. Not so of any particular character which botanists may fix upon. This may vary in a manner comparatively rapid, and thus it doubtless often happens that species really related and bearing a general resemblance are divorced in the text books on special differences.

This coexistence of so large a number of minor peculiarities as to give to two plants or groups of plants an obvious general resemblance should therefore be welcomed as a valuable accessory to the work of classification, not as a special guide to truth but as a general check upon error. A strong *physiognomic* resemblance between two groups of plants should at least raise a suspicion of their genetic relationship, and might frequently furnish a theory for the investigation of important questions. In a previous paper it was shown how the physiognomy of the *Cycadaceæ* pointed to their natural position between the ferns and the palms, and how a closer inspection of the more reliable characters sustained this conclusion. If now we return to the case of the *Ranunculaceæ* and *Rosaceæ* above referred to, we shall find a further confirmation of this law. A careful comparison of all the genera of these two orders, which has been recently made, reveals the fact that there is to be traced "an easy transition from the wholly conical and much elongated receptacle of *Ranunculus* and *Myosurus* to that of *Fragaria*, flattened at the base and conical in

the center, or of *Rubus* with its raised margin and convex center. From this we may pass to *Sibbaldia*, *Potentilla*, *Horkelia* and | *Stylobasium*."[3] On the same 730
principle the *Portulacaceæ* have been very closely assimilated to the *Cactaceæ*, with which they are found to agree in an astonishingly large number of characters, including that of the irritability of the stamens. Again the *Droseraceæ* and *Saxifrageæ* are now known to be closely allied families, as their physiognomy would indicate. And strange as it may at first appear, there is little doubt that the *Cruciferæ* are related to the *Onagraceæ* by natural affinities more or less close. Further investigations from the same point of view will doubtless enable us to go much farther in discovering the true affinities of dicotyledonous plants.

It is undoubtedly the special function of the floral envelopes, as it is of the ovary, to protect the germ, and the degree of this protection is the most reliable index we have to the degree of advancement in vegetal life. The means employed in securing this end in the *Dicotylæ* are twofold: first, the relation in which the calyx stands to the ovary; and second, the character of the inner envelope or corolla. Botanists, while they have not ignored either of these essential characteristics, have generally placed more weight upon the second than upon the first, although for the purpose named the first has doubtless been of equal service to plants.

From the hypogynous to the perigynous, and from this to the epigynous calyx-tube, there is certainly a steady progress in the direction of protection, and the advance of the calyx towards the more complete enveloping of the ovary may be regarded as indicating an equivalent advance in organization. In Dr. Lindley's great work on *The Vegetable Kingdom*, this was made the leading character, although in his earlier works he had followed the system of Laurent Jussieu; and Prof. Julius Sachs in his *Text Book of Botany*, though in most respects making an entirely new

[3] Baillon, *Histoire des Plantes.*

departure in botanical classification, places the *Rosaceæ*, *Onagraceæ*, *Myrtaceæ*, and other strictly epigynous families at the head of the system as representing the highest type of development.

The classifications by Divisions, on the other hand, professes to give special prominence to the corolla as an index of progress, but how obscure the notion of any direct ad-
731 vantage to be derived from it to the plant must have been with the founders of that sys|tem, is shown by the order in which the divisions were arranged. It seemed evident to their minds that those plants which were wholly destitute of a corolla, the apetalous or monochlamydeous Division, should stand at the base, and thus far they were certainly consistent. But in placing the polypetalous Division at the head of the system, the idea of its protecting function must have been quite forgotten. For unquestionably the monopetalous corolla is the form of floral envelope which affords the greatest protection to the ovary and stamens, and the more nearly this approaches to the tubular form the more complete is that protection. The distinct, usually spreading, and often fugacious petals of polypetalous plants are of very little service in this respect, so that, in so far at least as this one principle is concerned, they should certainly stand next above the *Apetalæ*.

In this respect too, it is true, certain monocotyledonous plants would take a higher rank than some apetalous and polypetalous *Dicotylæ*, their tubular perianths forming better protecting envelopes. But as it is the genealogical series that the new taxonomy seeks, other more fundamental characteristics must preclude all attempts to derive the *Monocotylæ* from any advanced stage of the *Dicotylæ*.

The general truth, which is becoming more and more apparent, is that the floral envelopes cannot alone be relied upon to indicate the course of development of the Dicotyledons, and that for the natural arrangement of the families many other considerations must be taken into the account.

Instead of depending upon any one character it is necessary to consider all the characters together. The task, it is true, is vastly more difficult, and systematic botany becomes a science requiring exhaustive study, but the conclusions reached will be correspondingly more valuable.

One of the best checks by which the genealogical systematist may frequently orient himself, is what has been called the "physiognomy" of plants. Whenever the pursuit of any particular character or set of characters is found to have brought into close proximity plants of a totally different physiognomy, it is generally safe to conclude that the process has been carried too far; and on the other hand, when, as is frequently the case in the present system, plants having strong general resemblances have been widely separated, the propriety of reviewing the evidence | on 732
which such separation was based is at least strongly suggested. The resemblance, above pointed out, which the *Caryophyllaceæ* bear to the *Polygonaceæ* illustrates this. In these orders the corolla and the ovary, two of the most reliable characters, are sufficiently distinct in typical genera to justify a separation, but when led by the stipules, swollen joints, leaves, habit, and other peculiarities that combine to make up their general appearance, to place them in juxtaposition and study them comparatively, we find that even these characters fail in certain genera, while the relationship indicated by the physiognomy is partially supported by more respectable evidence. We have already seen that several members of the chickweed family are apetalous. On the other hand some genera of the *Polygonaceæ* may be regarded as at least functionally dichlamydeous, as in *Chorizanthe*, the one-flowered involucre closely imitating a calyx. And further, the capsule of several genera of the *Caryophyllaceæ* (*Paronychia, Anychia, Scleranthus*) is reduced to a one-seeded utricle approaching the achenium of the buckwheat family.

While, therefore, the time has not yet arrived for the attempt to be made to trace out the line of genealogical

descent of the Dicotyledons, it is evident that a complete readjustment of the orders, to a great extent independently of the present Divisions, will have to be made and might soon be undertaken.

The first dicotyledonous plants were in all probability apetalous, and all authors agree in placing the *Amentaceæ* (*Juliflores* of Sachs) at the bottom of the scale. It is certainly not without significance that the *Casuarineæ*, whose possible descent from the *Gnetaceæ* (*Ephedra*) was referred to in the previous article, belong to this group.

The origination and development of the corolla was doubtless by a process similar to that by which the calyx was formed. In both cases it was the advantage, however slight, which the plant derived from it that occasioned its progressive development into a protecting organ. In the *Amentaceæ*, as also in many *Monocotylæ* (*Cyperaceæ*, *Gramineæ*), these envelopes are very imperfect, often reduced to mere scales. Polypetalous plants (and doubtless apetalous also) may be of two kinds, according as the petals may be shown to represent rudiments of a gamopetalous corolla in process of development, or only *vestiges* of one which they formerly possessed. The terms "polypetalous" and "monopet|alous" do not properly designate the process by which these organs are developed. According to the accepted principles of phyllotaxy, each petal (as also each sepal) represents a transformed leaf; but the embryological study of those plants in which the corolla takes the form of a tube, has proved that this has not been produced by the union of the original petals, but by the formation at first, of a ring at their base, which acquires greater prominence until it eventually assumes the character of a tube. To better indicate this process the terms "eleutheropetalous" and "dialypetalous" are employed by certain authors to denote that the petals are distinct, the term "gamopetalous" being used for the very objectional one "monopetalous."

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If natural selection has had anything to do with the

development of these organs, it is certain that the free petals must have historically preceded the tube, and hence we may conclude that for the earliest forms of each Division the order of succession was: first, *Apetalæ;* second, *Eleutheropetalæ*, and third, *Gamopetalæ*, and therefore to whatever extent these divisions may now be parallel and coördinate, they were not so at the outset.

If, therefore, we were to accord to the general principle of protection, as above pointed out, its full force in the classification of dicotyledonous plants, at the same time keeping in view certain subordinate laws by which it is qualified, we should probably find, in attempting to reconstruct the present system, that while the so-called Divisions would be virtually abolished and the orders within each very much blended and intermixed with those of the others, there would still remain an ascending series based on the perfection of the floral envelopes, and in which as now those plants classed as apetalous would in the main stand at the base. The intermediate terms of this series would, however, unlike the present system, consist chiefly of those orders now placed in the polypetalous Division, while the highest of these terms would be represented by the monopetalous orders with tubular corollas. This arrangement would be further modified by the relation of the calyx to the ovary and minor considerations. In fact, if the true genealogy of the *Dicotylæ* is ever worked out it will doubtless be found to conform to the general law in all departments of life, and to assume the arborescent form, whose ultimate ramifications it would be wholly impossible to trace in the present state of the science.

Very little more than this can at present be predicted with regard to what the true "Natural System" really is, which we are still so far from understanding; but it would seem from the peculiar character of *Compositæ*, and especially from the double safeguard of their narrowly tubular corollas, their epigynous calyx (*pappus*), and syngenesious anthers, still further secured by the massing of

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the flowers into dense heads, that this order, which is also the largest in the vegetable kingdom, should be regarded as the highest and most specialized family of plants, and might be fitly made to crown the natural system.

The general arrangement above outlined is further substantiated by the limited data which paleontology affords. The greater part of the fossil plants of this class have been found in the Cretaceous formation. They nearly all belong to the apetalous and polypetalous Divisions, but by far the greater number to the former; such genera as *Salix*, *Quercus*, *Platanus*, *Sassafras*, etc., occur most frequently, and some of these have been traced to the lowest Cretaceous strata if not to the Jura. That they existed in still earlier times can scarcely be doubted, and high authorities have fixed upon the Trias as the probable epoch in which the earliest dicotyledonous genera made their appearance. In the Upper Cretaceous certain polypetalous genera begin to be found, among which are numbered *Magnolia*, *Liriodendron*, *Prunus*, and other multi-staminate plants, most of which have been assigned a high rank in the current system. This fact and others seem rather to indicate that a great many stamens and an elongated receptacle are marks of a low organization, as if just emerging from the catkin-stage. Very few gamopetalous plants are found fossil, strongly implying that they belong to late Tertiary periods. Especially significant is the absence of those having elongated tubular corollas, while it is believed that the first fossil *Composite* plant is yet to be discovered.

Little, therefore, as is really known of the natural succession and actual genealogy of the Dicotyledons, we may, nevertheless, fairly claim to have acquired sufficient data to warrant entering upon the investigation of this difficult and complicated problem, a task which must owe a great share of its success to the aid to be rendered by a rational hypothesis.

December (?), 1878—Ætat. 57.

98. St. Louis and Botany

History.—Written Nov. 8, 1878.

Field and Forest, Washington, D. C., Vol. III, Nos. 10, 11, 12, April, May, June, 1878, pp. 170–172.

UNABLE, for a variety of reasons, to accompany the Colorado Excursion given to the members of the A. A. A. S. after the adjournment of the St. Louis meeting, I was obliged to content myself with such a glance at the flora of the nearer vicinity of the Metropolis of the Valley as the circumstances would permit. The chief opportunity afforded for this purpose was the very pleasant excursion to Iron Mountain and Pilot Knob, which was generously tendered us by the citizens of St. Louis and the railroad companies on August 24th. The heat was excessive and would have been well nigh intolerable but for the constant flow of cooling beverages, ice cream, etc., which the munificence of the local committee and managers made more free than water.

| At Iron Mountain, which is some two miles this side of Pilot Knob, the train halted and remained an hour to give members an opportunity to examine the mining region, which is truly wonderful. Notwithstanding the ninety-eight degrees of Fahrenheit, I sallied forth and made the circuit of the hill in which the principal mines 171

are located. The vegetation was decidedly meagre, the red turfless ground lay for the greater part entirely bare, but concealed here and there with clumps of *Phytolacca decandra*, *Diodia teres*, *Plantago Patagonica*, var. *aristata*, and a few other low weeds made up the only herbage.

I penetrated a short distance into a copse near by and was surprised to note the great extent to which the vegetation was familiar. But for the presence of *Galium lanceolatum*, *Gerardia quercifolia*, and one or two other plants, I might have supposed myself in some grove of second growth oak in Maryland or Virginia.

We were carried past our chief point of attraction, Pilot Knob, and taken to a place two miles further on called Arcadia. This was for the purpose of feasting us upon all the good things of the land, which was done out of doors under a great canvas on a series of long rustic tables which literally groaned under the load of viands which our generous hosts had prepared for us. This over, we returned to Pilot Knob, and most of the party climbed to its summit to view the surrounding country. While there we had the pleasure of seeing the sun set, the pleasure consisting chiefly in the reflection that it could scorch us no more that day.

Two plants of interest were found on the Knob, viz., *Vaccinium arboreum* (in fruit), and *Euphorbia heterophylla*, of which only a single specimen was collected near the summit. *Helianthus hirsutus* was also obtained at the base of Pilot Knob.

Owing to the barrenness of the whole iron region the number of interesting plants found there was quite small, and but for the opportunities which we enjoyed of getting off the train at several points along the route where stoppages were necessary for water, wood, etc., our collections would have scarce deserved this notice. But the vegetation along the railroad was much more abundant and interesting, and I was able to add to the species named a number of others that I was glad to obtain. Among those thus collected were:

Solidago radula, Panicum autumnale, Pycnanthemum pilosum, Verbena stricta, Erigeron divaricatum, Dysodia chrysanthemoides, Crotonopsis linearis, Hypericum Drummondii, Coreopsis aristosa (awnless). A species of *Desmodium* allied to *D. canescens* was also collected, but no satisfactory name has yet been found for it.

On the following day, while paying a visit to the city water-works, I added *Dalea alopecuroides* and *Potentilla paradoxa* to my Western trophies.

Our visit to the famous "Shaw's Garden" on the 26th will make a lasting impression. It would have been "glory enough" to have been able to stroll through and behold this truly wonderful, and to the botanist, intensely interesting park, but to be escorted through it by the venerable botanist, Dr. George Engelmann, and by him shown to the thousands of special curiosities, many of which he had himself introduced there, of which we were allowed to take specimens *ad libitum*, was indeed a treat, and one we shall long remember.

| An excursion on the 28th to Cahokia Mound in Illinois, five miles out on the O. & M. Railroad, [172] yielded the following species:

Boltonia glastifolia, Polygonum ramosissimum, Montelia tamariscina, Leptochloa fascicularis, Herpestis rotundifolia, Oxybaphus nyctagineus, Chrysopsis villosa, and Iva ciliata.

The country was mostly cultivated, and the fields not recently plowed were densely grown up to tall ragweed (*Ambrosia trifida*), which obscured the view even from the mounds.

I feel that I should be neglecting a manifest duty were I to omit the pleasant acquaintance made of Mr. George W. Letterman, of Allenton, Missouri, whose familiarity with the local flora was surprising, and only equalled by his freedom in imparting his knowledge and his zeal in assisting me to secure the best things obtainable. Not content with bringing to my room a valuable package of dried specimens collected and prepared by himself, for which I promised

to exchange our Eastern forms, he also collected at his home, and brought with roots, and living, a large number of species which we had failed to meet with on the excursions. Among these were some not found east of the Mississippi.

December (?), 1878—Ætat. 37.

99. Second Blooming

History.—Written November 7, 1878. The list is much extended in my *Guide to the Flora of Washington and Vicinity*, 1881. See "Autumnal Flowering," on pp. 32–33 of *Guide to the Flora of Washington and Vicinity.*

Ibid., p. 172.

THE number of plants occasionally blooming twice a year in this latitude is considerable and has already attracted the attention of botanists. This year I have collected the flowers of the following species at the dates appended:

Rubus villosus, September 22 and October 27; Viola pedata, September 22; Fragaria Virginiana, September 22; Houstonia purpurea, October 13; Vaccinium stamineum, October 13; Azalea nudiflora, October 13; Lonicera Japonica, October 13.

It will be observed that these are all "spring flowers." They bloomed regularly from April to June, went to seed, and then, during the hot months of July and August, lay as dormant as in mid-winter. The herbaceous species, *Viola*, *Fragaria*, and *Houstonia*, withered away almost entirely, and the flowers borne in autumn were on new plants that came out of the ground in September. In the shrubby forms the flowers were found on new green shoots

which had started afresh after the cooler and more moist weather had set in.

Could the September and early October weather continue a little longer many of these plants would yield two crops of fruit each year.

To the list above given might be added *Botrychium lunarioides*, which, though "booked" for July, is never found at that time here, but late in the fall. It does not come up until September or October, and develops the fertile frond in November or even as late as December. Our common form is the var. *obliquum*, but the var. *dissectum* also occurs and is truly beautiful. Until this season I had not been able to find fruiting specimens of the latter, though the sterile fronds were frequently associated with the other form. This year, however, I have been successful in securing a good supply.

September 20, 1879—Ætat. 38.

100. Homologies in the Lauraceæ

History.—Investigations and drawings made and paper written July 17–31, 1879. The paper was read before Section F, of the American Association for the Advancement of Science in Saratoga on September 2, 1879. The agent of the *Scientific American* asked me for it and I gave it to him. It appeared about the end of September, but I did not learn of it until November. There was an error in transposing the words "female" and "male" under the diagram of Sassafras, which is of course corrected here. This paper shows how greatly I was interested in the geological history of plants two years before I commenced its systematic study.

Scientific American Supplement, New York, Vol. VII., No. 194, September 20, 1879, pp. 3089–3090.

THE flowers of the *Lauraceæ*, although inconspicuous and unattractive, are interesting upon a close study. The interest chiefly arises from the presence within them of numerous so-called glands or functionless organs. In some cases the shape of these glands so strikingly suggests

the anther that we can scarcely hesitate to pronounce them rudimentary stamens. In other cases they consist of mere filaments or staminodia, which, as we shall see, may be abortive petals. In the male flower of *Sassafras officinale*, which is always dicœcious, there are six glands, all with anther-shaped heads on short filaments, arranged in pairs in a single whorl or row, each pair being joined at their base by a thin connective, out of the summit of which between the glands arises one of the three inner stamens, thus:

The floral envelope, which is considered monochlamydeous, consists of a six-lobed calyx with a very short tube, the divisions of the limb being so arranged that there are three outer and three inner, alternately imbricating over each other, thus:

There are nine true stamens, which are arranged in three rows of three each, and inserted on the tube below the lobes, the outermost row opposite the outer lobes, the middle row opposite the inner lobes, and the inner row again opposite the outer lobes, but on the connective between the pairs of glands as above shown. The pistil is wholly wanting.

In the female flowers of sassafras there are also six glands, which have more the appearance of stamens than those of the male flowers. They are situated opposite the sepals in a single row. These have been denominated rudimentary stamens by high authority, and there can be no doubt that they are such, although the anther-like heads now consist

of homogeneous tissue without cells. True stamens in the female flowers are wholly absent.

The male flowers of *Lindera benzoin*, a closely allied genus, are similar to those of sassafras in all respects except that they possess a rudimentary ovary. The female flowers of lindera, however, differ from the female flowers of sassafras in an important particular. Prof. Gray describes them as possessing "fifteen to eighteen rudiments of stamens in two forms." The normal number, however, is just fifteen, a greater number being sometimes found in the same way | that we sometimes find eight instead of six calyx-lobes. As regards the "two forms," nine of the fifteen 3090 are without glandular heads, and these are arranged in precisely the same manner as are the true stamens of the male flowers both of sassafras and of lindera. The remaining six have the anther-like heads, and are arranged in pairs like those of the male flowers.

Now, it is not probably doubted by any one that at one time the flowers of these two genera were perfect, *i.e.*, hermaphrodite, and this sufficiently accounts for the obsolete stamens of the female flowers of sassafras, but it does not explain why there are only six of these when the male flower has nine perfect stamens. Neither does it supply a reason for the six very similar glands of the male flower in addition to the true stamens. Still less does it account for the nine glandless and six gland-bearing rudiments in the female flowers of lindera.

In view of all the facts I, therefore, conclude:

1. That the six glands in the staminate flowers of both genera are the true homologues of the six rudimentary stamens in the fertile flowers of sassafras, and of the six gland-bearing rudiments of stamens in the fertile flowers of lindera.

2. That the nine polleniferous stamens of the male flowers of both genera are transformed petals of a former stage, in which the flowers were dichlamydeous.

3. That the nine glandless filaments in the female

flowers of lindera are the true homologues of the present stamens of the male flowers, which may or may not have once possessed anthers also.

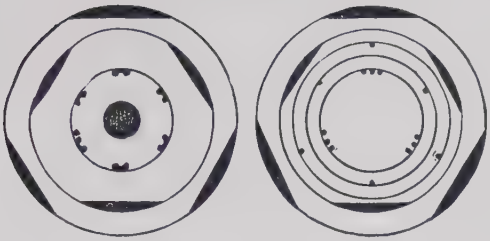
4. That at the time when the present stamens were petals the present gland-bearing rudiments were the true stamens.

The flowers of the *Lauraceæ* would therefore seem to have passed through a two-fold transmutation, having their petals first transformed into stamens, at least in one (the male) form, and then gradually losing their original stamens by their conversion into rudimentary glands. These not being injurious, but rather affording some protection, have not disappeared altogether, but remain very conspicuous objects. It is still a question whether to regard the nine glandless filaments in the female flowers of lindera as abortive stamens or as the remains of the original petals; in other words, whether the petals in the female flowers were ever really transformed into stamens, or whether they simply disappeared in sassafras and are now disappearing in lindera. I am disposed to adopt the latter view.

The peculiar connective joining the rudimentary stamens with the inner row of true stamens and of rudimentary petals in the female flowers of lindera may be explained by supposing that the original six stamens were situated one on each side of the three inner petals and inserted with them on the tube of the calyx.

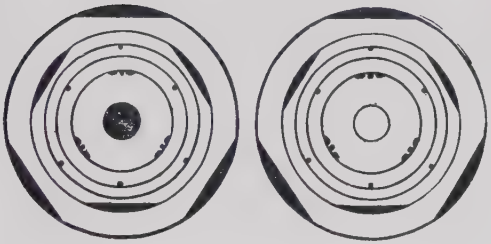
The two genera which I have described, therefore, and perhaps all the plants of the laurel family, must be supposed to have descended from a common progenitor in the remote past, which differed in some important respects from any plants now existing. This primordial ancestor of the Lauraceæ possessed dichlamydeous and eleutheropetalous, hermaphrodite flowers, with a six-parted calyx, the divisions arranged as now, nine narrow petals inserted in three rows on the calyx tube, the outer and inner rows opposite the outer lobes, and the intermediate row opposite the inner lobes; and six stamens inserted at the base of the inner petals, one on each side.

SASSAFRAS



FEMALE MALE

LINDERA



FEMALE MALE

PROTOTYPE

HERMAPHROOITE

The following diagrams, representing cross sections of each of the forms now found, and also of the original from which all are supposed to have been derived, will serve to illustrate the progress of the changes which have taken place. The inner circle represents the gynœcium, which is not drawn when wanting, and not filled out when abortive. The next three whorls embrace the present androecium, as also the primordial petals. In the female of sassafras only one of these (the innermost) occurs representing the primordial androecium, now the anther-like glands. The two outermost whorls denote the lobes of the calyx. In the ancestral form the nine petals are represented as somewhat ligulate, a stamen on each side of each of the three inner ones.

At first view it may be thought that this is an extreme and complicated metamorphosis for a flower to undergo, but it must be remembered that a vast period of time has been required to effect it. We know as well as we know anything about plants, that the flowers of many of them are actually in a transition state. The number of species that any botanist can call to his mind in which the sexes are only partially separated and apparently in a vacillating condition between hermaphrodism and diclinism is very great. They occur in families the most widely separated botanically, and illustrate all shades of the process. Even lindera, which we have been studying, differs from its close relative, sassafras, in this respect. The rudimentary pistil in the male, and the rudimentary petals (or stamens) in the female flowers, both of which have long since disappeared from sassafras, plainly show that the latter is, so to speak, a much older genus, and commenced its career of transmutation ages further back in geologic time; and we may also with some certainty predict that lindera, too, will one day lose these useless vestiges. Nor are we restricted for time in the case of the *Lauraceæ*. Vegetable palæontology teaches that this is one of the oldest families of flowering plants. Its fossil remains are found deep down in Meso-

zoic strata. Prof. Lesquereux detects no less than seven genera of this order in the Dakota group of our American cretaceous formation. Among these occur a number of species of sassafras, but the absence of lindera is quite significant in view of its morphology, as above pointed out, indicating a more recent origin. These plants have therefore had, at least, the entire cretaceous, tertiary, post tertiary, and modern periods in which to undergo these changes, so that we only need assume the same measure of differentiation which we are certain is now taking place, to account for any modification which their present morphology may require to have taken place in the past.

101. [Timber Trees and Grasses of Utah]

History.—As I was a member of Major Powell's Survey in Utah in 1875, he naturally called upon me for a report on the timber trees and the grasses of the region in which I operated. I wrote such a report August 6–7, 1878, and submitted it to him. He embodied it in the second edition of his *Report on the Lands of the Arid Region* under the two heads: Timber and Grasses, in such a manner that the two subjects are separated by about eight pages of his own discussion of these subjects. The Report did not reach me until November 13, 1879.

Report on the Lands of the Arid Region of the United States, with a more detailed account of the Lands of Utah. By J. W. Powell. Second Edition, Washington, 1879, pp. 100–103; 108–110.

[Timber Trees]

THE forests of these upper regions are monotonous, as the variety of tree life is very small. All of the timber trees proper are coniferous, and belong to the pine, fir, and juniper families. The pine of chief value

is *Pinus ponderosa*, locally distinguished as the "Long leaved pine"; the wood is very heavy and coarse grained, but is suitable for the ruder building and mining purposes. It is usually found on the slopes between eight and nine thousand feet above the level of the sea. It attains a large size, and is a stately tree, contrasting grandly with the darker and smaller firs that usually keep it company.

Pinus aristata is of no commercial value, as it is much branched and spreading with limbs near the base; it grows on the crags at an altitude of from nine to eleven thousand feet.

Pinus flexilis grows at the same altitude as the last mentioned, and often shows a similar habit of growth. On the southern plateaus it is less branched and has a tolerably straight trunk, but it is too small and scarce to be important as timber. It is highly resinous, and is called "Pitch pine."

Pinus monticola, or Sugar pine, is found on the southern plateaus, but is not abundant, and rarely attains milling size.

Pinus edulis is the well known "Piñon pine." It covers the foot hills and less elevated slopes adjacent to the river valleys. The tree is low, diffusely branched and scrubby, and is of no use for lumber; but the wood is well supplied with resin and makes an excellent fuel, for which purpose it is extensively used in consequence of its accessibility.

There are three valuable species of Abies, namely: *A. Douglasii*, *A. concolor*, and *A. Engelmanni*. *Abies Douglasii*, or Douglas' spruce, bears some resemblance to the eastern spruce, *A. Canadensis*, but it is a finer tree, and the wood is much superior. Though rather light, it is tough and exceedingly durable. The heart wood is red, from which circumstance lumbermen distinguish it as the "Red pine." In building it is used for all the heavier parts, as frames, joists, rafters, etc., and it makes excellent flooring. Its value is further enhanced from the fact that it occupies a belt of from seven to nine thousand feet altitude, and thus

is easily obtained. It may readily be distinguished by its cones, the bracts of | which are trifurcate, sharp- 101
pointed, and conspicuously exserted, and they are unlike those of any other species.

Abies concolor, known in Utah as the "Black balsam," grows at about the same altitude as the last mentioned species, and though rather cross-grained makes good lumber, being quite durable and strong. From its silvery foliage, the leaves being glaucous on both sides, this tree is known to tourists as the "White silver fir." Lumbermen sometimes call it the "Black gum," the wood being very dark colored.

Abies Engelmanni, or Engelmann's spruce, occupies the highest elevations, and constitutes the only timber above 11,000 feet in altitude. Above 11,500 feet it is reduced to a dwarf. On the terraces of the high plateaus, at about 10,000 feet altitude, it appears to flourish best, and here it becomes a large, beautiful tree. The leaves are needle shaped, and thus differ from both the preceding species. The trunks are straight and free from limbs or knots, making fine saw logs. The wood is white and soft, but fine grained and durable, and being easily worked, is held in high esteem for all the lighter uses, such as sash, doors, etc. Its place in the lumber industries of Utah is about the same as that of the "White pine" (*Pinus Strobus*) in the east. Lumbermen usually call it "White pine." Because of the altitude of its habitat it is difficult to obtain, yet it is systematically sought, and large amounts are yearly manufactured into lumber; it also makes good shingles.

Abies Menziesii, or Menzies's spruce, usually called "Spruce" by lumbermen of the country, is botanically very similar to the species last described, but the cones are larger and the leaves sharper pointed. It bears a large quantity of cones, which are generally aggregated near the top, obscuring the foliage, and giving the trees a peculiar tawny appearance. The wood is light, white, and fine grained, and would rival that of the last named species

but for the fact that the trunk has a number of slight curves, so that it is impossible to obtain good saw logs of sufficient length from it. Its habitat is along the cañons from seven to nine thousand feet altitude, and seems to end about where *A. Engelmanni* begins. It is, however, a smaller tree, and less abundant.

Abies subalpina is of little value as a timber tree; the wood is | soft and spongy, from which circumstance
102 it is locally known as "Pumpkin pine," but the more appropriate name of "White balsam" is also applied to distinguish it from *A. concolor*, which is called "Black balsam." This species grows high up on the mountains and plateaus, generally from nine to eleven thousand feet. It is very tall, often attaining a height of 80 or 90 feet. Its trunk is straight and limbless for a great distance. This species has been but little known to botanists heretofore, from the fact that it has been confounded with *A. grandis*, but Mr. Engelmann decides, from specimens collected by Mr. L. F. Ward, that it must be considered as a new species.

Abies amabilis and *Abies grandis*, spruces resembling the "White balsam" in their general appearance, occur in the Wasatch Mountains, but are not abundant.

Juniperus Californicus, var. *Utahensis*, or White cedar, is very abundant over the foot hills and lower mountain slopes, and like the piñon pine, is much used for fire wood. It has also the characteristic durability of the junipers, and makes excellent fence posts. It grows low, is diffusely branched, and is valueless for milling purposes.

Juniperus Virginiana, or Red cedar, is also found in this region. Its habitat is near the streams and at moderate altitudes. It is said to lack the durable qualities for which it is noted at the east, and which seem to be transferred to the other species.

Populus angustifolia, or Cottonwood, is the chief representative of the poplar family in this region. The people of the country distinguish two varieties or species,

the Black cottonwood and Yellow cottonwood. The former is said to be useless for lumber, while the latter has some slight value. It forms no part of the forest proper, but fringes the lower reaches of the streams, rarely occurring higher in altitude than 6,000 feet. Its rapid growth and its proximity to the irrigable lands make it valuable for fuel, although it is not of superior quality.

Populus monilifera, the Cottonwood of the Mississippi Valley, grows with the above in the southern part of the Territory, and has about the same value.

Populus tremuloides, or Aspen, is found about the moist places on the | mountain sides, and often borders the glades of the plateaus. The long poles which it fur- 103
nishes are sometimes used for fencing purposes; it makes a fair fuel; the quantity found is small.

Acer grandidentatum, a species of Maple, abounds at the north as a bush, and rare individuals attain the rank of small trees. Its wood is highly prized for the repair of machinery, but is too scarce to be of great service.

Negundo aceroides, or Box elder, is found along the water courses in many places. Sometimes along the larger streams it attains a height of 25 or 30 feet. It makes a good fuel, but is found in such small quantities as to be scarcely worthy of mention.

Quercus undulata, or White oak, is very abundant as a bush, and sometimes attains a diameter of six or eight inches. It is too rare as a tree to deserve more than mere mention.

Betula occidentalis, a species of Birch, grows about the upland springs and creeks. Its habit is bushlike, but it often has a height of 20 feet, and it makes a tolerable fuel.

The Hackberry (*Celtis occidentalis*) and two species of Ash (*Fraxinus coriacea* and *F. anomala*) grow as small trees, but are exceedingly rare.

The above is a nearly complete list of the forest trees of Utah. The number of species is very small; aridity on the one hand, and cold on the other, successfully repel the de-

ciduous trees. The oak, hickory, ash, etc., necessary to such a variety of industries, especially the manufacture of agricultural machinery, must all be imported from more humid regions. The coniferous trees, growing high among the rocks of the upper regions and beaten by the cold storms of a long winter, are ragged and gnarled, and the lumber they afford is not of the finest quality; and the finishing lumber for architectural purposes and furniture must also be imported from more humid regions.

108 [Grasses]

Of the bunch grasses the *Poas* are by far the most abundant. Of this genus nine species were obtained, but this gives an inadequate idea of the variety. Of one species alone Dr. Vasey has enumerated nine varieties, and advances the opinion that several will be eventually considered as species. They are found at all altitudes, mostly on the slopes. Perhaps the most important single species in that region is the *Bouteloua oligostachya*, the so called "Circle grass." It has a peculiar habit of forming partial or complete circles on the ground, with areas of bare ground in the center. These turfy rings are comparatively narrow, often not more than three or four inches in width, while the circles are from two to four feet in diameter. The form is not always circular, but often assumes irregular shapes. The grass is sweet and nutritious, but its chief value consists in its power to resist inclement seasons, as it cures standing, like the "Buffalo grass" of the Great Plains.

Another very valuable grass is the *Eriocoma cuspidata*, which is known by the name of "Sand grass." It grows at much lower altitudes, and is properly a valley grass. It has a solitary, scattering habit, or at least the bunches are small and turfless. Horses and cattle select it with care from among other species, and it seems especially nutri-

tious. It has a large black grain, which is often collected by the Indians for food.

A remarkable lowland grass is the *Vilfa* (*Sporobolus*) *airoides*. It has something of the appearance of "Hair grass," with a widely spreading purple panicle and large perennial roots. The old culms persist at the base, and with the new ones form thick and almost woody tufts. These tufts are scattered about in the strongly akaline soils of the river bottoms, and are extensively pastured by large herds of cattle. A marked characteristic of this grass, common, however, to several others, is its power to take up saline matter, which gives to the whole plant a salty taste. The effect of this upon the stock feeding upon it is doubtful, judging from the conflicting reports of the inhabitants; but it seems that when cattle are first pastured upon it they are injured by the excess of salt, but that after a time they | cease to be injured by it. 109 All of the so called "Salt grasses" are cropped to a greater or less extent by stock.

The chief grasses of the elevated timber tracts belong to the genus *Bromus*. When young they are good, but they become stale and valueless with age. The only grass that can compare with those of the eastern meadows, and which forms a continuous sod and covers the ground with a uniform growth, is a variety of *Aira cæspitosa*, a red-topped grass, which was found surrounding the small lakes of the mountains and plateaus, at elevations of 11,000 feet and over. This is an exceedingly beautiful grass as it waves in the gentle breezes that fan the lakelets of the upper regions.

Phragmites communis, the so called "Cane," is common in the glades and sloughs; and, though large and rather dry, it furnishes the only verdure obtainable for months in severe seasons.

Much of the hay and pasturage of the country, which is there called grass, consists of plants of different families. Notable among these are several species of *Carex* (sedges),

particularly *Carex Jamesii*, which springs up wherever artificial meadows are made by the system of flooding commonly practised. The plants have large, strong, subterranean rootstocks, forming a tangled mass which, when once established, cannot easily be eradicated. The leaves are broad and grasslike, and, though coarse and comparatively insipid, form a good sward which can be mowed—a rare condition in that country; and hence such meadows are highly prized.

Juncus Balticus, var. *montanus*, which has a blue color, terete culms, and tough fiber, and which the settlers call "Wire grass," is very abundant. It is cut for hay, and is said to serve a good purpose as such.

There are some shrubs that furnish excellent browsing, among which, perhaps, the greasewood takes the first rank. The sage brush, *Artemisia*, on the contrary, is seldom resorted to. There is one shrub to which great virtues are ascribed which may be mentioned in this connection. This is the *Cercocarpus parvifolius*, which occupies the mountain sides for a wide zone of altitude. The foliage, though not strictly evergreen, remains most of the winter,
110 and is said to afford the only food for horses and cattle | that can be obtained during some seasons of deep snows. This shrub is a congener of the well known mountain mahogany, *C. ledifolius*, which grows at higher altitudes, and has truly evergreen foliage.

The small perennial plant *Eurotia lanata*, or "White sage," found growing in the valleys and plains, is held in high esteem as winter food for stock.

March, 1880—Ætat. 38.

102. Sexual Differentiation in Epigæa repens[1]

History.—The plants first studied were collected April 20, 1879, near Sligo Creek, northeast of Washington. I studied some of the flowers the next day and found the stamens abortive, but I did not follow up the investigation at that time. In July, when I decided to attend the meeting of the American Association for the Advancement of Science in Saratoga, I took it up as the subject for a paper, and on July 11th I gave the flowers a thorough investigation after soaking them well. The paper was written July 15–30, and read before Section F on September 1st. I sent the paper to Professor Cope for the *American Naturalist* on November 16th, but it was long delayed.

The American Naturalist, Philadelphia, Vol. XIV, No. 3, March, 1880, pp. 198–200.

THE following remarks on *Epigæa repens* are contained in Gray's "Synoptical Flora of North America," under the generic description of that plant:

"The flowers are heteromorphous and inclined to be

[1] Read before the American Association for the Advancement of Science, at Saratoga, N. Y., September 1, 1879.

dicœcious, or dicœcio-dimorphous. Those with fully polliniferous anthers seldom set fruit; their stigmas short, erect, slightly projecting beyond the margin of the five-toothed ring (to the teeth of which they are severally adnate), the style sometimes longer than the stamens and projecting, sometimes shorter and included. Fully fertile flowers on other plants; their styles (as in the former sort sometimes long and exserted, sometimes shorter and included) with stigmas elongated and much surpassing the ring, short, linear, glutinous, radiately divergent; their stamens either slightly polliniferous, or reduced to abortive filaments, or even wanting."

In the early spring of this year I took occasion to make some careful observations on this plant as it occurs in the vicinity of Washington City, the results of which, though in the main confirmatory of this description, differ from it in some respects, and afford some additional facts of special interest.

I desire to premise that these variances and additional peculiarities are doubtless due to differences of habit in different localities, and not to any lack of fidelity in description.

The principal deviation which I detected from the description which I have quoted, was in the styles and stigmas. I found no heterostyly; the length of the styles relatively to the flowers was about the same at all times in both forms of flowers. The stigma, however, presented a very different appearance in one form from what it did in the other. In the fertile form, in which the abortive stamens varied in all degrees, the lobes of the style were strongly divergent and of a firm texture, with evident stigmatic surfaces. In the staminate form they were never separated, but cohered tightly in an apparently solid club-shaped summit or head.

199 I was able, however, to dissect them apart without | lesion, and satisfy myself that they were entirely functionless, possessing no stigmatic surfaces.

The important *addition* which my observations furnished

to the facts described by Prof. Gray, consisted in the discovery that the dimorphism of the flowers extends in a marked degree to their *dimensions*. The staminate flowers are, in all respects, much larger than the fertile ones. As this fact at first appeared quite remarkable, I took great pains to verify it, making my comparisons from specimens taken from localities widely separated, and repeating the observations a great many times throughout the flowering season of the plant. It grows on gravelly slopes in small areas or patches, and all the flowers in a patch were invariably found to be of the same kind, either all staminate or all fertile, as if all came from the same root, as no doubt they do.

The amount of surface covered by staminate plants was found greatly to exceed that covered by the fertile ones. It thus often required considerable search to find a patch of fertile flowers, but a little practise was sufficient to render their detection easy from the diminished size and conspicuousness of the flowers. This difference does not consist merely in the greater vigor and turgidity of the staminate form, but represents an actual discrepancy in the measurements of all the parts of the flower, amounting to about thirty per cent in the length and about forty per cent in the width of the corolla. The exact dimensions, as taken from typical specimens, were as follows:

Length of flower including calyx and limb of corolla:		
In staminate form	16	millimeters
In fertile form	12	"
Width of corolla tube split through and laid open:		
In staminate form	11	"
In fertile form	7	"
Width of limb of corolla laid open in the same manner:		
In staminate form	15	"
In fertile form	9	"
Length of the pistil, including ovary and stigma:		
In staminate form	9	"
In fertile form	7	"
Length of perfect stamens	9	"
Length of sterile filaments	3	"

The staminate form appears never to develop fruit, although the ovary contains ovules. The fertile form, besides being much more rare in actual amount at flowering time, and possessing decidedly less fragrance, also often fails to fruit. It is, therefore, only quite rarely that fruiting specimens can be found. I attribute this, however, to the failure of most of the fertile flowers to receive any pollen. The two forms are often not in close proximity. They bloom very early in the spring, before most of the flying insects appear. The flowers are always close to the ground, with their open end more frequently inclining
200 downward than upward, and most of them are concealed under the foliage so as to | be invisible from above. Yet, as we have seen, their self-fertilization is impossible. These and other facts have led me to the conclusion that, where fertilized at all, it is chiefly done by ants, which, on the theory now generally accepted by entomologists, of the possession by that insect of a keen sense of smell, would sufficiently account for the exquisite fragrance of the flowers of Epigæa. I have failed entirely to find insects within the corolla, but this, so far from causing doubts that it is fertilized by insect agency, simply helps us to understand why it bears fruit so sparingly.

The facts which I have stated, even if they were entirely new, which they probably are not, might not, perhaps, in themselves have justified me in claiming for them the attention of this association. For my own part I am far more interested in the important principles which they illustrate, and it is for the purpose of stating these principles, supported by such an example, that I have been led to present the facts.

Besides affording an instructive example of the many ways in which plants are dependent upon insects, Epigæa well illustrates the process of sexual differentiation which is going on in a great many species of plants. In the maples it has not yet advanced so far; in Smilax it has gone somewhat farther, while in the willow it has reached completeness. It is in these intermediate stages that the phenomena

are most interesting, and the botanist, contemplating a great number of these, differing by small degrees, can almost see the process in operation. The phenomena of dimorphism, as it exists in Houstonia, must probably be regarded as one of the initial steps in the direction of ultimate diœcism, or complete separation of the sexes.

In this respect, as in many others, we find that nature cannot be assumed to have reached its final and fixed condition, but that the existing state of things must be regarded as dynamic; the movements in the past which have made things what they are, still continue to effect changes in them. There is a sort of *uniformitarianism* in biology as well as in geology, and the law of "present causes" is as potent in explaining the existing condition of plants and animals as it is that of coast lines or mountains.

Hermaphroditism, or self-fecundation, seems to be a thraldom necessary at the outset, but from which all living things are seeking to escape. The animal kingdom has, for the most part, thrown off this yoke, chiefly through the development of the sexual instinct. The vegetable world still groans heavily under it, but it is now looking to insects as its liberators, and the little flower which I have figured here, shows one of the many ways in which these creatures perform this service.

103. The Relation between Insects and Plants, and the Consensus in Animal and Vegetable Life[1]

History.—As stated in the foot-note of the Editor, this paper was read at the St. Louis meeting on August 27, 1878. An outline sketch of it was drawn up on August 17th and 18th, before I left for St. Louis on the 19th. It was finished at the hotel in St. Louis after my arrival, but had to be compressed into a fifteen minute paper. As such it was read, but when Professor Riley, who was there and heard it, subsequently asked me to contribute it to his newly started *Entomologist*, I expanded it considerably on January 22 and 23, 1879, and sent it to him on the 24th, in its present form. It remained in his hands for more than a year.

The American Entomologist, New York, Vol. III, New Series, Vol. I, No. 3, March, 1880, pp. 63–67; No. 4, April, 1880, pp. 87–91.

[1] This paper, read at the St. Louis meeting of the A.A.A.S., was placed in our hands in the Fall of 1878 when we expected to commence the publication of the *Entomologist*, and with the author's permission has been held by us since that time.—Ed.

THE object of this paper is rather to show the importance of a more connected study of these two great departments of Natural History than to present new facts in either of them. The prevailing practice of isolating them and carving out of each a number of exclusive specialties, while it is necessary and advisable within certain limits, nevertheless allows, when universally followed, a large class of important | phenomena ly- 64
ing on the border-land between them, to escape entirely.

It is an old truth that many animals subsist on vegetables. It is a newer truth that all animals depend altogether, either directly or indirectly, upon plants. It is a still newer truth that many plants are partially or wholly dependent for their existence on certain animals.

The power of plants to manufacture protoplasm and starch has no parallel in animal physiology. Viewed from their relations to the inorganic world, plants are producers while animals are parasites.

True, there are organisms which, from morphological considerations, are called plants, but which are also parasites. And there are other organisms which have been and still are called animals, but which originate organic matter. But these are only illustrations of the difficulty in attempting to preserve popular names which were applied to things before science had taught us the nature of the things themselves. And this question of names is still further complicated by cases in which both functions are performed by the same individual. We may remand *Volvox* and the *Bacteria* to the vegetable kingdom and the fungi to the animal, but what shall we do with the mistletoe, the pine-sap, and the broom-rape? The terms "animal" and "plant" do not express the fundamental distinction which nature makes between the two departments of life; and when we attempt to define that distinction by saying that the true vegetal function is *chemical* while the true animal function is *physiological*, the terms thus employed

must be taken in a special scientific sense and not in the popular acceptation. Giving them this sense we can correctly say that there are large groups of organisms in which both animal and vegetable functions are performed by the same individual, whose reference to the one or the other of the two kingdoms is a pure matter of convenience, to be determined chiefly by morphological considerations. Still clinging to our definition, we may also correctly declare that all animals subsist exclusively on the products of vegetation. They are parasites in the highest sense, fully installed parasites, the respectable ruling classes, who never think of work. The so-called parasitic plants, on the other hand, are degenerate tramps who combine a little drudgery with much *unsystematic* plunder, thus rendering themselves unpopular. And it may be generally stated that the tendency of all life is to escape this drudgery of organic production wherever an opportunity presents itself, and this it does even where great degeneracy is the necessary result.[1] I certainly need not point out here the parallel between the two great sciences of Biology and Sociology.

Leaving these general considerations relative to the fundamental dependence of animal upon vegetable life, I propose to call attention to some facts of a more practical nature coming under the same head.

It is of course chiefly as food that animals appropriate plants; but there are many and varied ways in which this takes place, and the extent to which certain animals are nourished by certain plants exerts a great influence upon both the floras and faunas of the various regions of the globe, thus bearing directly upon the problems of geographical distribution. The introduction of a new animal into a region in which it did not previously exist often so greatly alters the vegetation in a few years that it would scarcely be recognized. Such an effect has been produced in South America by the introduction of horses which have become wild and now roam in great numbers over the pampas.

[1] Ernst Haeckel, *Ueber die Individualität des Thierkörpers*, pp. 10, 11.

And even small animals produce effects which seem quite out of proportion to the cause. The operations of man in changing the face of Nature, when scientifically viewed, constitute an illustration of the same truth. Of all the migratory animals man exerts the most profound influence upon the flora of the globe. He not only exterminates certain species and fosters others, as do other | animals, but, by a system of artificial selection which he 65
to a great extent unconsciously practices, he effects the most extraordinary modifications in the plants themselves, illustrations of which it would be quite superfluous to adduce.

When to these considerations we add those arising out of the relations which insects sustain to plants we are brought face to face with the most practical questions of horticulture and agriculture, a thorough acquaintance with which is of the utmost importance. To this same group also belongs the extensive subject of *galls*. This study is essentially compound and belongs to botany as well as to entomology. The gall presents a case in which, in the normal condition, the plant is the loser, yet there is reason to believe that such is not universally the case. The whole subject has been so exclusively given over to the entomologist that it may be safely predicted that whenever it shall be phytologically studied much valuable knowledge will be added to that already acquired. Plants are not generally killed by the bite of the insect. This would defeat the end the insect itself has in view. The normal channels of circulation and growth in the plant are simply blocked up and forced to re-form under new conditions favorable to the insect. The case is analogous to those in which man turns the channels of streams to his own advantage or in any manner diverts the forces of Nature in his own favor, which is the essence of invention and of all material progress. In neither case is Nature actually defeated, it is only controlled. In the gall the insect has learned to control the forces of growth to its own advantage.

Where the same insect operates in the same manner upon

the same plant for many generations a certain adaptation must take place. The abnormal mode of growth must become to a certain extent normal. We may even suppose cases in which the presence of the gall has come to be a benefit rather than an injury. I have myself observed many cases in which it appeared in no way to arrest the normal function of the plant. Specimens of *Eupatorium album* recently collected exhibited a swelling in the peduncle at the base of each head, in the center of which was a hollow cavity enclosing the larva. But the tissue all round this cavity seemed perfectly healthy and the flowers were in all states of advancement and apparently wholly unaffected by the gall. A remarkable gall which I found on the prevailing juniper of the Wasatch range, *Juniperus Californica*, var. *Utahensis*, deceived everybody but professional naturalists by its resemblance to fruit, and though abundant in certain localities, did not seem in the least to impair the growth of the trees. Oak galls, as all know, are green; they contain chlorophyl and must perform the regular functions of assimilation. The insect producing a gall may be regarded as a parasite on the particular plant chosen whose growing tissue the larvæ usually devour at something near the rate at which it forms. There are cases both where plants are parasitic on plants (e. g. lichens on fungi[2]), and where animals are parasitic on animals,[3] in which the foster individual is benefited, and that such should sometimes be the case with plants regularly affected by the same gall is not antecedently improbable.

With these few remarks on the first general division of the subject, or that in which the dependence of animal life upon plant life is shown, we may now pass to the second division, which includes the evidence of a reciprocal dependence of the plant upon the animal.

That quadrupeds and birds are perpetually conferring great service upon many forms of plant life there is now no

[2] Sachs, *Lehrbuch der Botanik*, p. 330.

[3] Van Beneden, *Animal Parasites and Messmates.*

doubt. This is done chiefly in securing their proper distribution over the earth. Were the seeds of plants compelled to depend upon gravitation and the winds alone for their distribution the relative proportions of the various species would be very different from that which we actually find. In many cases the seeds, berries, and nuts | falling directly to the earth, would spring up in such dense 66 clumps as to choke each other and endanger the life of all. Every species has to pass through a certain ordeal in the history of its struggle for existence, at which period any, even the smallest, additional obstacle to its progress is sufficient to turn the scale against it and force it to succumb. It is at this time that a wide distribution is of the greatest advantage. With most of the choicest nut and fruit-bearing species this is the case, and had no other agency existed for accomplishing this purpose than those of inorganic nature it is doubtful whether they could have survived. This great service is performed by animals and by birds in a variety of interesting ways.

The full significance of the many remarkable kinds of fruit can only be understood by recognizing this principle. But it must also be remembered that the adaptation has been mutual. We cannot assume the various fruits to have first existed and that afterwards the animals and birds came upon the stage and accomplished their distribution. The development of both has gone on *pari passu* from the beginning, and this also harmonizes in a suggestive manner with the known simultaneous geological appearance of these higher forms of vegetable and animal life. Under the law of natural selection, now the fundamental principle of biological dynamics,[4] berries and fruits have gradually acquired attractive dimensions, tastes and colors,[5] while the true

[4] That department of biology which takes account of the changes that have taken place and which are constantly taking place in the form, habits, location and numerical relations of living things.

[5] In *Medeola Virginica*, the Indian Cucumber-root, I have suspected that the brilliant red color of the upper whorl of leaves which accom-

germinal portion, (seeds, drupes, &c.) have been protected from destruction in various ways, and thus the animal world has been employed to distribute the vegetation, for which labor it receives its own subsistence as a remuneration. Not always, however, is compensation thus meted out, for in the many kinds of burs, by whose aid the plant is equally benefited, the task of distribution is an involuntary and unwelcome one to the creature performing it.

But interesting as these considerations are, and pointedly as they show the intimate connection subsisting between the physical life of animals and plants, they are nevertheless trite, in comparison with the astonishing facts which a study of insect life in its relation to plants reveals.

Whether it be true or not, as queried above, that plants may in certain cases derive benefit from insects through the agency of galls, it is now certain that they do derive such benefit in at least two other entirely distinct ways; viz., 1: by the action of the insects in cross-fertilizing flowers; and 2: by the action of plants in entrapping insects and appropriating them to their own nourishment.

Considering the first of these modes, that of cross-fertilization, it is surprising to what extent the evidence already obtained, and that by comparatively few observers, supports the conclusion that for the higher forms of vegetation this reciprocity is one of equality, and that the vegetable kingdom is as absolutely dependent upon the animal as the animal is upon the vegetable. This fact of insect agency in cross-fertilization which Sprengel, its original observer, appropriately styled "The newly-discovered Secret of Nature," has been so far established and extended by recent observation that it has become the key to the greater part of the mysteries of vegetable morphology. In fact it has so enlarged our conceptions of the science that the peculiarities of structure observed in flowers are no longer looked upon as positive facts (I use the term *positive* in the

panies the ripening of the berries located at its base, may have been developed through natural selection for the attraction of birds.

Comtean sense) but as effects, and we at once proceed to interpret their significance and determine their true cause or *raison d'être.* Just as when the archæologist discovers a singular vessel or implement he refers it to the agency of an intelligent being who must have constructed it, so the modern botanist, when he sees a curious structure in a flower, proceeds by a course of rational deduction to account for it as | the result of insect agency. The parallel, how- 67
ever, holds only so far. The manner in which the result is produced, as also the motive of the agent, being widely different in the two cases.

New facts are being continually added to prove the extent of this influence. There is scarcely a flower in our woodlands or meadows whose attentive study does not teach us something of it. Upon them all these tiny creatures have impressed their stamp. It is now extensively maintained that all that makes flowers attractive to us, their brilliant hues, their fragrant odors, as well as their size and form, are the fruits of the industry of the insect microcosm as slowly brought about through ages of time. That celebrated couplet in Gray's *Elegy Written in a Country Churchyard:*

> "Full many a flower is born to blush unseen,
> And waste its sweetness on the desert air,"

was the product of the knowledge of the 18th century and is no longer true. Showy and fragrant flowers are the consequence of a true psychic force, of an æsthetic faculty identical with that of man, and our admiration of them simply proves that we admire what the insect world admires, and that there is a standard of taste which holds not only for mankind but for all sentient beings.

| It is a fact of profound significance that the higher 87
flowering plants made their first appearance on the globe simultaneously with the *Hymenoptera* and *Diptera* in the Jurassic and Cretaceous formations, while they did not

reach their highest perfection until the *Lepidoptera* had appeared in the early Tertiary. The *Neuroptera* and *Orthoptera* which are found in the Carboniferous could have contributed nothing to the demand for cross-fertilization, and the *Coleoptera*, sparingly met with below the Trias, were doubtless then equally ineffectual in this respect; as even at present they only supplement to a slight degree the work of the bees, flies, moths, and butterflies. And we accordingly find that the vegetation prior to the Jurassic and Cretaceous epochs consisted almost wholly of Cryptogams and Gymnosperms, with only a few amentaceous and monochlamydeous Angiosperms in the highest of these strata.

These facts justify the assumption that most of the higher flowering plants would speedily perish were insect aid withdrawn, and also that but for such aid in the past we should now see, instead of our gorgeous flora of Orchids, Lilies, Magnolias, and Roses, one consisting chiefly of Ferns, Cycads, and Conifers, mingled with willows, oaks, and alders, and plain grasses and rushes.

But when we consider how poorly adapted Cryptogamous and Coniferous vegetation is to the support of animal life, we may also declare with perhaps equal certainty, that but for the *Phaenogamia* there could have been no *Mammalia*. A picture that should represent herds of buffaloes and antelopes roaming amid the Ferns, Lepidophytes, and Calamites of the Carboniferous epoch would be an anachronism whose realization it would be impossible to conceive. And thus we have, only on a grand scale, one of those singular chains of cause and effect of which naturalists have pointed out several (that of the dependence of clover upon cats, being perhaps the most familiar), but which, apart from that grotesqueness which they sometimes possess on a superficial view, are among the best illustrations of that intimate and far-reaching *consensus* which pervades all departments of life.

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Considering to what extent man is dependent upon the *Palmaceæ*, *Rosaceæ*, and other fruit and nut-bearing trees

and plants, which, at least on the theory of man's simian origin, must have been far greater if not absolute in the early period of his existence; considering, too, in connection with this, that it is the *Hymenoptera* that have contributed most to render the existence of this class of vegetation possible, it ceases to be a mere poetic fancy to claim for the bee and the ant the high merit of having literally prepared the way for the advent of man, whose prototype they are to so great an extent, both in their psychic and their social attributes.

The works of Darwin, Lubbock, Hildebrand, and Hermann Müller, contain an immense array of evidence bearing upon this interesting subject of cross-fertilization by insect agency, and I will only refer to a few typical cases peculiar to this country, and for the most part omitted in those works. Our American flora certainly presents as promising a field for this line of research as that of any other portion of the globe. Our Orchids are more varied and beautiful than those of Europe, and their peculiar forms doubtless embody lessons not yet imparted to man. The *Asclepiadaceæ* of which we have a rich abundance, depend wholly upon insects to extricate the pollen-masses from the deep cells in which they would otherwise remain permanently imprisoned. Our Mountain Laurel, *Kalmia latifolia*, has its anthers embedded in pits in the corolla from which, when freed by insects working at the nectar tubes below, they fly back by the elastic spring of the filaments, and cast their pollen to distant flowers. *Houstonia purpurea* and *H. cærulea*, as also *Mitchella repens* and other *Rubiaceæ* furnish marked examples of heterostyly, while cases of dichogamy are common among the *Geraniaceæ*, *Umbelliferæ*, *Compositæ* and *Gentianaceæ*.

Science is indebted to two distinguished citizens of St. Louis, for the double discovery that our beautiful *Yucca filamentosa* is fertilized wholly by insect agency, and that this is accomplished by a single species of insect without whose services it can not bring forth fruit.

Most of you doubtless remember the brilliant paper by Prof. C. V. Riley, read at the Dubuque meeting of this association in 1872, in which these discoveries, the first made by Dr. George Engelmann and the second by himself, were announced, and *Pronuba yuccasella* was formally christened.

This case has an especial interest in connection with the general subject of this paper, since it illustrates more pointedly than any other within my knowledge, the nature of that *consensus* which exists between the insect world and the world of flowers, and at the same time forcibly demonstrates the necessity of studying these two sciences in connection.

Without enumerating additional instances, I may be permitted to refer to my own recent observations on *Sabbatia angularis*, whose curious behavior seems to me to admit of no other interpretation than as designed to secure the prevention of self-fertilization.

This flower, which is very showy and handsome, contains 5 stamens with elongated, sagittate, introrse anthers, which are abruptly curved outward near the summit, and a single style about as long as the stamens terminated by a forked stigma nearly as much longer, the commissure being often visible as a distinct line to near the base of the style.

These branches of the style which are stigmatic on the inside, are at first closely twisted together in such a manner as to conceal the stigmatic portion. They afterwards untwist and present the simply bifurcate appearance.

The plant is protandrously dichogamous and this untwisting of the stigma lobes does not take place until the anthers
89 have | shed their pollen, so that the pollen of later flowers must be conveyed by insects to the stigmas of earlier ones. But in addition to this, the style itself is abruptly bent near the base, so as to form an angle of from 45 to 90 degrees with the perpendicular, carrying the stigmas far away from the stamens and usually locating them between the lobes of the corolla. Still more remarkable, how-

ever, is the fact that in most cases the stamens also are bent, but always in precisely the opposite direction from the style, so as to lean conspicuously away from the center, and it was not difficult to find flowers in which these peculiarities were carried so far that both the style and all the stamens were found lying flat upon the floral envelopes and pointing in opposite directions. Later, however, and after fecundation has taken place, both the style and the stamens partially or completely resume the vertical position.[6]

The aid which insects render to plants in procuring cross-fertilization is not their only service in return for the work of assimilation performed by the roots and leaves which constitutes the plant the true producer in the organic economy. Many of them sacrifice their lives to the needs of the plant and the plant appropriates the bodies of its insect prey as systematically as does the swallow or the fly-catcher. If the great mass of insects, along with other animals, devour plants for their sustenance, so do certain plants as regularly devour insects for their sustenance, and not a few are the cases in which the imago pays back to the plant with its life and its body the board-bill which it contracted in the larval state.

This fact which was so long denied and then doubted, is now, thanks to the labors of Charles Darwin, fully established, and it exhibits another important side of that closely-woven web which holds the two kingdoms together.

[6] Since the presentation of this paper and the subsequent publication of my observations in the *Gardener's Monthly*, it has been kindly pointed out to me by Prof. Asa Gray that the dichogamous ("*protandrous*") nature of several Sabbatias (*S. chloroides*, *S. stellaris* &c.) as well as the peculiar position of the style, had been previously noticed in his works. "The opposite position of the stamens," he however adds, "is quite new to me." * * * "We had not noticed this in the stamens of *S. chloroides* nor in *S. stellaris*." My observations were repeated in 1879 and the results, accompanied by drawings, were communicated to the Association at its Saratoga meeting. They fully confirmed the above description.

The number of Insectivorous Plants is far greater than was at first supposed possible, and it is by no means probable that all of those endowed with this attribute, even among species systematically well known, have yet been recognized as belonging to this class.

There are two distinct ways in which plants appropriate insects, for the entrapping of which many remarkable devices exist. One method is almost wholly analogous to that by which the same function is performed by animals and constitutes a true digestion, the insect being decomposed by the action of a gastric juice, and the materials already assimilated passing directly into the circulation of the plant. The other method consists in the absorption by the roots and lower parts of the plant of the highly nitrogenous liquor formed of the decayed bodies of insects dissolved in rain-water. The first class utilize the insects as *food*, the second as *manure*. Exhaustive experiments have proved that in both these ways the plant is benefited and a true nourishment derived. Plants of this kind, of necessity, partially lose their power, both of radical and of parenchymatous assimilation, and become in so far parasitic, but strange as it may sound, parasitic on animals.[7]

Interesting as are these physiological facts, the morphological changes which take place in plants to adapt them to insectivorous habits, are if possible still more remarkable.

As in cross-fertilization it is the flowers, so in insectivorous plants it is the leaves which exhibit these modifications and perform these functions. The leaves of insectivorous plants are usually radical, and the organic matter derived from the bodies of insects finds its way through their porous petioles to the region of the roots, whence it enters directly into the circulation, as if taken from the soil.

90 | Mr. Darwin, in his excellent work on *Insectivorous Plants* has described most of the species then known. He has, however, omitted several of our American species belonging to the second class, or manure-generating plants.

[7] *Empusa muscæ* is a kind of mould parasitic on the house-fly.

Of these I may mention *Sarracenia purpurea*, the well known pitcher-plant. Its brown-purple color denotes that it lacks the usual supply of chlorophyl, and its singular pitcher-shaped root-leaves generally contain a dark fluid with numerous drowned insects in all stages of decomposition. The stiff bristles on the inner face of the so-called "hood" have been described, but the much longer and slenderer hairs at the bottom or small end of the pitchers seem to have been overlooked.[8] These cover the inner surface of the pitchers, commencing at the base, extending about one-fourth of the way to the top, and terminating abruptly all round at the point where the pitcher begins rapidly to enlarge. I found them all closely appressed with their free ends uniformly pointing downward, and although they are more slender than would be thought most effective, there can be little doubt that they constitute an efficient snare for small insects venturing down into the narrow portion to which they are attracted by a savory secretion.

In Darlingtonia, an allied genus from the Pacific coast, an excellent description of which may be found in the *Botany of California*, the mechanism for accomplishing the same purpose is still more complicated and well illustrates the astonishing lengths to which morphological modification may be carried to secure these apparently unnecessary ends.

Cuphea viscosissima, a little plant in the natural order *Lythraceæ*, and a congener of the common garden Cigar-plant, is, as its name implies, "most viscid" throughout its stem and branches, which are densely covered with gland-bearing hairs. These serve as effective fly-traps, being usually found more or less covered with small gnats, and I have more than once found full-sized flies adhering by their feet. Although it is difficult to understand how this plant succeeds in utilizing the prey thus caught, it is perhaps more difficult to believe that all this cruelty is entirely wanton

[8] Prof. C. V. Riley has observed and describes similar hairs in *Sarracenia variolaris*. See Proc. A. A. A. S.

and purposeless. But aside from optimistic considerations, it is not easy to account for the development of any wholly useless mechanism. The reddish color of the stem of this plant marks a deficiency in chlorophyl and points in so far to a probable partially parasitic habit, and though no movements take place in the glands,[9] an internal circulation and "process of aggregation" may reasonably be assumed to go on.

America furnishes in *Dionæa muscipula* the most perfectly adapted insectivorous plant known to botanical science. Its wonderful mechanism and behavior have been faithfully portrayed both by Mr. Wm. M. Canby and Mrs. Mary Treat, as also by Mr. Darwin, and my own limited observations upon it simply confirm, so far as they go, the results obtained by them. I mention it merely as an illustration of the rich field which this country presents for the investigation of all these questions.

The entire subject-matter of this paper is without a specific designation or name, and without a place in any existing classification or curriculum of the sciences. We have zoölogy, and we have botany, and we have entomology, but neither of these embraces any of the above-named phenomena, or at most, only half of each phenomenon.

I should therefore fail to justify its presentation were I not to point out, in conclusion, the importance of bringing botany and entomology, at least into more intimate connection. The botanist who is unfamiliar with insect forms is never attracted by them when seen in and around flowers, drowned in the troughs, or caught in the viscid secretions of insectivorous plants. Thus the observation is only half made. I state this as a confession, and it is a confession
91 which every thought|ful collector in either field must have often made to himself. The collector must know his plant as well as he knows his insect, and *vice versa*, in order correctly to interpret either the peculiarities in the form

[9] Prof. Thomas Meehan, *The Native Flowers and Ferns of the United States*, vol. 1, p. 43.

of the one or the peculiarities in the conduct of the other. However it may be with other departments of biology, the importance and the feasibility of combining as one science or specialty an acquaintance, systematic at least, with plants and insects, or if this be thought too much, such an acquaintance with Phænogamous plants and with the *Lepidoptera*, *Hymenoptera* and *Diptera*, cannot be doubted. In no other way can the proper observations be made to exhibit the true relations which subsist between these organisms. It is a rare occurrence that a botanist and an entomologist collect in company, and should they do so, the results would still be less satisfactory than where both are combined in the same individual. Far be it from me to urge a departure from the practice of choosing specialties and mastering such specialties. In no other way can true excellence be attained. Neither is it often possible to make all forms of life a specialty. There will never be many Charles Darwins. But considering the remarkable interdependence which I have sought to point out between certain entirely dissimilar forms of life, which obviously can never be fully understood by specialists in any one department, it seems a necessity, if we would ever understand these questions, to combine the study of portions of two of these departments into one specialty and to prosecute them conjointly. There could thus be secured a corps of competent workers, specialists in this field, without which no great subject can ever be thoroughly canvassed.

Zoö-phytology, or the science of the relations which subsist between animals and plants in general, is an ideal science whose general aspects can be grasped only by a few minds of high synthetic capacities. But Entomo-phytology, or the science of those relations of interdependence existing between certain insects and certain plants, and which may be said to embrace the three subjects of galls, cross-fertilization of flowers, and insectivorous plants,—this science, when pruned of everything not necessary to the investi-

gation of the problems to which this interdependence and reciprocity give rise, may certainly be regarded as a practical one whose pursuit would be attended with abundant success.

104. Pre-social Man [Abstract]

History.—After reading my paper by this title before the Anthropological Society of Washington on April 20, 1880, I loaned the same to Mr. Edward T. Peters, who was then working on the Washington *Critic*, and he reported the proceedings of the meeting for that paper and copied the following literally from my manuscript (see *infra*, No. 111).

The Daily Critic, Washington, D. C., April 21, 1880.

IT might safely be given as the opinion of those naturalists who accept the animal origin of the human race that at some time and in some part of the world some one group, possibly a very limited one, of the ape family acquired certain of the characters which now distinguish the human from the simian anatomy. These characters are as follows: Increased capacity of the cranium and increased size of the encephalon; greater complication in the mechanism of the larynx; the erect posture of the body; the plantigrade character of the feet; non-opposability of the great toe; diminished length of the arms in proportion to the trunk; greater or less absence of hair from most of the body and limbs; double curvature of the spine. Among

these points of difference there was a certain interdependence, so that on the principle of direct equilibration, they would all flow from some one or two of the chief ones, and the first of these characters to be acquired by the simian ancestors of our race must have been the increased size of brain, which might have resulted from the necessity certain apes were under of depending on superior cunning for protection against animals of greater strength and ferocity than themselves; and this character once acquired, together with the modifications resulting from the substitution of terrestrial for arboreal habits, the rest would follow. The immediate progenitor of man among the anthropoids might have been considerably nearer to the human form than any of the known anthropoids now are, as would be the case if there were a creature combining the full chest of the gibbon, the skull of the chimpanzee, the short arms and manlike hands and feet of the gorilla, the size of brain of the orang-outang and the features of *Semnopithecus*, *Cercopithecus*, or *Mormon*. That such a form once existed was as reasonable as that the gorilla or orang-outang should exist. The fact that we have no fossil remains of such a being proved nothing, although it was not impossible that the remains of this "missing link" might yet be found when paleontologists came to explore the regions in which alone it could have existed.

105. Feeling and Function as Factors in Human Development [Abstract]

History.—Written August 29, 1880. The history of the paper itself will be given under the next title.

The Boston Advertiser, Boston, Vol. CXXXVI, No. 54 [22,469], September 1, 1880, pp. 1, 4.

MR. LESTER F. WARD, of the Treasury, in discussing "Feeling and function as factors in human development," said that the phenomena of human development may be contemplated from two quite distinct points of view, only one of which has thus far received sufficient attention. These two points of view are those respectively of feeling and of function, and it is the first of them that has been neglected. According to the usual method of approaching such questions, man is regarded as a being requiring for his preservation a certain amount of nourishment, and for his perpetuation the begetting of offspring. The two essential factors from this point of view are the functions of nutrition and reproduction. Around the first of these cluster the industrial activities, and upon the second is founded the family. Out of these grow all the later and more complex characteristics of civilization. According to the other mode of contemplating

human development, man is regarded as a being endowed with feeling. These feelings are in the nature of desires. The existence of such desires involves the effort to gratify them, which effort in turn gives rise to human activities. The condition of society at any time is the result of these activi|ties. Just as, from the point of view of function, nutrition and reproduction, were the two primary essential factors; so, from the point of view of feeling, the gustatory and sexual appetites are the primary and essential factors. The advantage of the latter method over the former is that it affords, as the other does not, a scientific basis for the investigation of the laws of anthropology. The action of an organism in seeking the satisfaction of a desire finds an exact parallel in the action of a chemical molecule in seeking combination with others, or that of a column of air in rushing in to fill a vacuum. The desires of individuals constitute true forces, identical in all respects with the physical forces which other sciences deal with, and all branches of anthropology, including that of sociology, at once take their places as true sciences. This antithesis may perhaps be rendered more striking by considering function as the object which nature seeks, and feeling as that which man seeks. The object or end of nature is the preservation and perpetuation of existing life; that of man, and of all beings endowed with feeling, is the gratification of existing desires. The former is objective and constitutes a biological process; the latter is subjective, and is a moral or sociological process. The essayist then proceeded to consider the nature of desires as the proper subjects of scientific study, and a diagram was presented showing how these true social forces admit of being classified. The necessity of excluding intellectual action from the list of social forces was insisted upon, and the contrast between intellect and feeling pointed out. It was finally shown how, from the proper point of view, all human actions are capable of being classified, and such a classification was presented in tabular form.

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106. Feeling and Function as Factors in Human Development [1]

History.—Written September 29, 1880. This is the paper in the most detailed form in which it appeared, that I read before the Anthropological Section (E) of the American Association for the Advancement of Science in Boston, August 31, 1880. I had on the previous day placed the table of classification of the social forces on the blackboard. I had full notes that I had prepared before leaving Washington, and the paper was read largely from the manuscript folios of my *Dynamic Sociology*, then completed and seeking a publisher. It was really part of Chapter VII of that work, and the table scarcely differs from that on page 472 of the first volume. Prof. F. W. Clarke had asked me for an abstract of it for the Boston *Advertiser*. This I had written on the 29th and handed to Professor Clarke after I had read the paper. It appeared in the *Advertiser* the following morning (see the preceding title).

I should not have published this paper in any

[1] Read before the A. A. A. S., Boston, 1880.

more expanded form had not Mr. John Michels, who had recently established a weekly journal called *Science*, asked me to do so for that journal. This request reached me Sept. 29th, and that same evening I drew up the paper in the form here presented. This, therefore, constitutes the earliest publication of my classification of the social forces. This was the beginning of the journal *Science*, which has continued until now, and is to American science what *Nature* is to British science, but it was soon turned over to a staff of scientific men. A new series was started in 1883, and the original series in which this paper appeared has been systematically ignored. Few know of its existence.

Science: A Weekly Record of Scientific Progress, New York, Vol. I, No. 17, October 23, 1880, pp. 210–211.

SOCIOLOGY is now recognized as a legitimate branch of Anthropology.

The great French philosopher, Auguste Comte, although the first to introduce the word *Sociology*, did not venture to use this term extensively himself, but preferred the expression *Social Physics*, which must therefore be accepted as the true definition of sociology as intended by the father of the science.

It is important to remember this fact and to preserve throughout this necessary connection between social science and physical science. This, however, has not always been done. The phenomena of human development may be contemplated from two quite distinct points of view, only one of which has thus far received sufficient attention. These two points of view are those respectively

of feeling and of function, and it is the first of them that has been neglected. According to the usual method of approaching such questions, man is regarded as a being requiring for his preservation a certain amount of nourishment and for his perpetuation the begetting of offspring. The two essential factors from this point of view are the functions of nutrition and reproduction. Around the first of these cluster the industrial activities, and upon the second is founded the family. Out of these grow all the later and more complex characteristics of civilization. According to the other method of contemplating human development, man is regarded as a being endowed with feelings. These feelings are in the nature of desires. The existence of such desires involves the effort to gratify them, which effort in turn gives rise to human activities. The condition of society at any time is the result of these activities. Just as from the point of view of function, nutrition and reproduction are the two primary essential factors, so, from the point of view of feeling, the gustatory and sexual appetites are the primary and essential factors. The advantage of the latter method over the former is that it affords, as the other does not, a scientific basis for the investigation of the laws of anthropology. The action of an organism in seeking the satisfaction of a desire finds an exact parallel in the action of a chemical molecule in seeking combination with others, or that of a column of air in rushing in to fill a vacuum. The desires of individuals constitute true forces, identical in all respects with the physical forces which other sciences deal with, and all branches of anthropology, including that of sociology, at once take their places as true sciences. This antithesis may perhaps be rendered more striking by considering function as the object which nature seeks, and feeling as that which man seeks. The object or end of nature is the preservation and perpetuation of existing life; that of man, and of all beings endowed with feeling, is the satisfaction of existing desires. The former is objective and constitutes a biological process;

the latter is subjective, and is a moral or sociological process.

Properly understood these processes possess no natural or necessary relation to each other. It is easy to imagine a person wholly destitute of taste. Indeed such cases are on record. The pleasure derived from the contact of nutritious substances with the tongue and palate is obviously distinct from the benefit which it confers upon the system after digestion. Such a person as we have supposed would none the less need food because he had no desire to partake of it.

It is still more easy to conceive of a total absence of the sexual instinct, and this is a much more common pathological condition found in practice. Here the feeling is still more obviously distinct from the function.

Why then do these desires and their functional results so universally accompany each other? The answer is that this apparently "preëstablished harmony" of things having no necessary relation or resemblance has been the result of natural adaptation.

The agreeableness of the acts of nutrition and reproduction exists because without it nutrition and reproduction could never be secured. The existence of these pleasures,
211 | as of all other pleasures, and all pain also, is explained on the theory of selection.

It is desire alone which leads to action. Among the lower animals it is the momentary impulse which always determines action. Hence these, if destitute of these passions in the gratification of which they preserve their existence and continue their kind, would speedily perish.

In man both these desires are strong and constitute the motive, either direct, or indirect, to the greater part of his acts.

There are of course other desires, many of which may be regarded as derived from these, but some of which are apparently also original and natural, but whatever they may be, they are in the nature of forces, and all the desires taken

together may be appropriately called the *Social Forces*. These social forces readily fall into two groups, and each of these is capable of subdivision into subordinate groups, as the following table will show:

- Essential Forces.
  - Preservative Forces.
    - Positive, gustatory (pleasurable).
    - Negative, protective (painful).
  - Reproductive Forces.
    - Direct: The sexual instinct.
    - Indirect: Parental and consanguineal affections.
- Non-essential Forces.
  - Esthetic.
  - Emotional.
  - Intellectual.

Space forbids the elaboration of this table, and indeed it scarcely requires it. I will only say a word on the last group named in it, the intellectual forces. Upon this point much confusion, and as I think, error prevails. It is at the present time at least, a very small and uninfluential group. Properly it embraces nothing beyond the mere yearnings of the intellect. Its only basis is the pleasure of intellectual action.

I strenuously object to throwing the whole effect of mind in social development into the class of social forces. The social forces are indeed psychic, but they are not intellectual. The intellect is in no true scientific sense a force. It is not a motor influence.

It is characteristic of every true natural force that the body impelled or attracted by it moves in a straight line from the impelling or towards the attracting object. If it move in a curve or any but a straight line this is always due to a plurality of forces acting in different directions. This is true of all the social forces. Desire, wholly unaccompanied by reason, always impels in a direct line towards its object. This is illustrated most clearly by the acts of the lower animals.

The fly buzzing against the transparent pane until exhausted, without sufficient intelligence to try another locality, is an example daily witnessed. Moths seeking a

flame regardless of its destructive power, and rising with scorched wings, plunging anew into the fatal charm, show the action of a force scarcely higher than the purely mechanical. It is so with every form of desire. But for the intellectual agency, to however slight a degree, all animal action, human action included, would be of this direct character. The influence of mind sustains the same relation to the true forces of desire that the rudder of a ship, moved by the helmsmen, sustains to the sails acted upon by the wind. As it is not the former that propels the ship, so it is not mind that propels society. The great results which are collectively termed civilization are the direct outcome of these impulsive social forces, guided, of course, by intellect or reason. All the efforts that have been put forth have been made solely for the satisfaction of present desires. The end really reached has not been the end sought. Function has been totally ignored and feeling alone consulted. The ends of Nature have been attained, not directly as objects of pursuit, but only indirectly through the means of Nature which are the ends of the feeling creature.

It has been remarked that owing to adaptive influences these naturally independent lines, leading respectively to the ends of Nature and the ends of the sentient organism, converge to the same point. The effects produced by obeying the desires in most cases are the effects necessary to preserve, perpetuate, and develop the organism. But here is the fundamental distinction to be noted. These functional effects are secondary. It is not to secure them that the acts are performed. The beings performing them take no thought of them. The only effect in the mind of the agent is the satisfaction of a present desire. It may be safely said that this is almost universally the case even in human action.

But it may be asked what difference it makes, inasmuch as the indirect or functional end is always secured by the previous harmony brought about by adaptation.

With non-progressive beings like the lower animals, it

may be admitted that it makes but little difference. Here the chief interest centres on biological questions, questions of anatomy, histology, morphology, etc., and therefore the objective or biological standpoint is usually, though not always, sufficient. But with man, a progressive being, whose actions transform the entire face of the planet and lift him by rapid steps from one plane of activity and life to another, it becomes of the utmost importance that the true nature of his motives be scientifically understood; that the effects produced be attributed to their true immediate causes and not to indirect or merely incidental ones. Nutrition is not an end of human conduct in seeking food; it is the satisfaction of hunger. A family is rarely a direct desideratum in human life. Every physician knows how often it is an object of dread. It is only an incident. The great blessings of accumulated wealth have never been the immediate object of industry and financiering skill. These are the direct results of that great derivative passion called avarice which has been so unjustly condemned. Industry, commerce, art, and often invention flow from the "love of money," which has been most superficially called "the root of all evil," when it is really the root of nearly all good in civilization. Labor is performed and heroic deeds achieved not to make the world richer and happier or set examples of nobility for future ages, but to secure the immediate wants of the individuals performing them, to gain money and applause, to win the fair and to support them. Avarice, ambition, love, each has accomplished its direct results in the true civilization of the race.

October 30, 1880—Ætat. 39.

107. Quercus Leana, Nutt

History.—Written September 20, 1880. The last visit to the spot was made on the preceding day.

The Botanical Gazette, Crawfordsville, Indiana, Vol. V, No. 10, October, 1880, pp. 123–125.

IN an article on the "Oaks of the Potomac Side" which I contributed to *Field and Forest* for October and November, 1875, occurs the following remark: "Two trees which I have recently discovered in a wood near the northwestern (northern) corner of the District of Columbia, have proved unusually interesting. That these should be called *Quercus Leana* and not *Q. heterophylla* I maintain for the following reasons: Their resemblance to *Q. heterophylla* as it exists in the herbarium of the Department of Agriculture is not sufficiently close to warrant this name, the leaves being broader and less lobed. They *do* agree substantially with the specimens of *Q. Leana* in that herbarium. They also agree remarkably well with the tree which Mr. W. R. Smith, Superintendent of the U. S. Botanical Garden, has raised in his grounds from an acorn of *Q. imbricaria*. Finally, on considering the locality in which these trees were found, it seems impossible to believe that *Q. Phellos* can have entered into the combination. In the entire

wood where they are situated not an individual of that species exists. It is wholly wanting throughout the region of Rock Creek on which the grove is located. On the contrary the prevailing oak there is *Q. imbricaria*, although both varieties of *Q. coccinea* are also frequent. It cannot therefore be justly claimed that this new discovery constitutes a revival of the famous Bartram's Oak, since this was decided on the highest authority to be either a form of *Q. Phellos* or a union of that species with *Q. coccinea* var. *tinctoria*. It is, however, none the less a botanical curiosity."

Since the above was published I have re-visited the locality no less than five times and have succeeded in obtaining an abundance both of fruiting and flowering specimens, of which I may say, *en passant*, I have a supply for distribution and exchange. My latest visit was | made a few days ago, this time in company with Dr. George Vasey, 124 Botanist of the Department of Agriculture. As there has been of late a perhaps somewhat healthy reaction against the hybrid theory, doubtless too often invoked in explanation of aberrant and intermediate forms, I will briefly describe our conjoint observations upon the oaks in the vicinity of the trees to which reference has already been made. Our problem was if possible to satisfy ourselves whether these oaks were really hybrids, and if so what species were to be regarded as their putative parents.

It should be premised that on both these trees (which I am now satisfied proceed from a single root, although separate at the base) the lower leaves differ widely from the upper ones, the former being much larger and either entire and oblong or only slightly lobed or angled at the apex, thin and green both sides. I had frequently met in that locality with trees bearing none but these large, thin, smooth, oblong leaves which I had attributed to the effect of shade upon the true *Q. imbricaria*. At no great distance from these trees were found specimens of *Q. imbricaria*, *Q. coccinea* and *Q. palustris*. A little way off we came upon a

spot where there stood a large and typical tree of each of these species, the three trees forming a regular triangle, and just in the center of this triangular space there grew what appeared to be another double tree somewhat smaller than that which I have so often visited. I had frequently seen these before and observed that they bore the large and thin, smooth leaves with the outline of those of *Q. imbricaria*. We now observed that the larger of the two trunks bore leaves resembling the lower leaves of our *Q. Leana*, i. e., mostly lobed or angled at the end. On looking carefully up into the tops of these trees manifest signs of lobation were visible in the leaves even of the smaller trunk. This was, however, confined to the apex and often amounted to nothing more than an irregular obtruncation. On the larger trunk the leaves were very decidedly lobed among the upper branches quite clearly approaching those on the fruiting branches of the typical *Q. Leana*. As neither of these trunks had as yet commenced bearing fruit it seems very probable, as Dr. Vasey remarked, that at their maturity the leaves of these trees will assume the normal form of the hybrid.

The fact that *Q. palustris*, which was present, belongs to so distinct a group of oaks, with the shallow cup, seems to be tolerably conclusive against this hybrid having sprung from the union of that species with *Q. imbricaria*, and the only remaining explanation makes these trees a cross between the last named species and *Q. coccinea*, which was the conclusion at which I arrived on first discovering the other pair, and which is expressed in the paragraph quoted at the outset.

Recurring now to the question whether these trees are really hybrids or not, it seems as if no rational mind, brought into actual contact with the facts as they presented themselves in their plain, straightforward way, could resist the conviction that the pollen from a lobed-leaved form had fertil-
125 ized the stigmas of the entire leaved form, or | *vice versa*, and that these variable, intermediate, and unstable

states had sprung from acorns thus crossed. And this is the consideration which I wished specially to emphasize. It is often and truly said that persons unfamiliar with any special branch of natural science are incapable of appreciating the nature and force of scientific convictions. This would be preëminently true in this case. Standing in the presence of these forest denizens, I felt that they were speaking to me and revealing to me the secret of their conception, birth, and life, in a language more potent and convincing than any words or voice could make it.

108. The World's Supply of Live Stock

History.—Written September 8 to October 13, 1880. I had always been interested to know, as nearly as possible, the number of large animals actually under domestication in the world. The reasons for this curiosity are stated under another head (see No. 115). The documents I was obliged to handle, as librarian of the United States Bureau of Statistics, seemed to be adequate to this purpose, and I spent much time compiling these statistics. I had thought of scientific results only, but when the article was complete it was not only not adapted to any scientific journal, but it had a market value for the stockman and brought a fair price. My title was: *The Animal Population of the Globe* (see *infra*, No. 115), and I am not responsible for the present title nor for the flaming headlines of the newspaper.

The Chicago Times, December 18, 1880, pp. 8–9.

ON THE HOOF

THE WORLD'S SUPPLY OF LIVE STOCK AS SHOWN BY THE LATEST AND MOST RELIABLE STATISTICS

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THE CATTLE, HORSES, HOGS, SHEEP, ASSES, AND MULES OF THE WORLD CALLED UP AND ENUMERATED

TABLES WHICH EXHIBIT THE POPULATION OF FARM ANIMALS OF THE ENTIRE GLOBE

COMPARATIVE CONDITION OF THE LIVE STOCK SUPPLY AT VARIOUS PERIODS

GREAT PROMINENCE OF THE UNITED STATES AS A STOCK-RAISING NATION

THE TIMES has compiled from a variety of sources, chiefly official, the following statistics of live stock in all countries of the world where any data exist upon the subject:

GREAT BRITAIN

The agricultural returns of Great Britain give the enumeration as made in June of each year for England, Scotland, and Wales, which was as follows for the years 1879 and 1880:

	1879	1880
Horses	2,347,845	.....
Cows	2,255,236	.....
Cattle of all kinds	5,856,356	5,912,046
Sheep	28,157,080	26,621,724
Hogs	2,091,559	2,000,722

IRELAND

The registrar general for Ireland has issued a preliminary report on the agricultural condition of the island, from which the following figures are taken for the past two years, the

enumeration being made, as in the case of Great Britain, during the month of June of each year:

	1879	1880
Horses and mules	596,890	582,053
Asses	188,839	186,245
Cows	1,464,652	.....
Cattle of all kinds	4,067,758	3,921,026
Sheep	4,017,903	3,561,361
Goats	278,843	265,688
Hogs	1,072,185	849,046

From these two tables it appears that the number of domestic farm animals in the United Kingdom, and particularly in Ireland, is decreasing.

FRANCE

The latest enumeration for France is for the year 1876, and is contained in the "*Statistique de la France*," tome 6. Compared with the two previous years, the different kinds of animals were then distributed as follows:

	1874	1875	1876
Horses	2,747,531	2,754,842	2,852,419
Mules	295,700	283,404	294,352
Asses	411,484	407,042	416,868
Cows	7,343,370	7,315,222	7,307,087
Oxen and bulls	2,447,646	2,376,746	2,366,081
Calves	1,695,321	1,666,173	1,678,052
Cattle of all kinds	11,486,337	11,353,141	11,351,220
Sheep, indigenous	20,948,296	20,907,468	21,035,295
Sheep, choice breeds	2,989,040	2,850,747	2,866,782
Sheep of all kinds	23,937,336	23,758,216	23,902,077
Goats	1,684,873	1,629,854	1,587,040
Hogs	5,486,694	5,629,617	5,801,002
Total farm animals	46,049,955	45,821,116	46,204,978

It will be observed that upon the whole the number of live stock is increasing in France, although the year 1875 showed some temporary diminution.

GERMANY

The latest official enumeration in Germany was made on the 10th of January, 1873, at which time, according to the "*Statistik des Deutschen Reichs*" (Bd. VIII., S. 4, 114), there were:

	In the German empire	In Prussia
Horses	3,352,231	2,232,435
Mules	1,626	934
Cows over 2 years old	8,941,221	5,077,860
Other cattle over 5 years old	1,679,935	825,195
Cattle of all kinds	15,776,702	8,639,514
Sheep	24,999,406	19,666,794
Goats	2,320,002	1,481,461
Hogs	7,124,088	4,294,926

Previous enumerations were made in the different states at different times, so that comparison can only be made in each state. They show a slight annual increase from 1861.

RUSSIA

The British "Statistical Abstract of Foreign Countries" gives the latest official statistics of Russia, which are for the year 1870. We shall compare this with the estimate of Dr. F. X. Neumann-Spallart, director of the Austrian statistical commission, as published in his "*Uebersichten ueber Production, Verkehr, und Handel in der Weltwirthschaft,*" 1879, which he intended to represent the average from 1865 to 1877:

	1870	1865–77
Horses	16,160,000	.....
Cattle	22,770,000	23,601,000
Sheep	48,132,000	48,585,000
Hogs	9,800,000	10,332,000

AUSTRO-HUNGARIAN EMPIRE

The "*Statistisches Jahrbuch*," of Austria, for 1876 (Heft 2, p. 15,) gives the number of live stock in Austria proper for the year 1869, which we compare with Hungary for the same year, the latest obtainable in both cases:

	Austria	Hungary	Total empire
Horses	1,384,623	2,158,820	3,543,443
Mules	11,723	3,266	14,989
Asses	31,351	30,480	61,831
Cows	3,829,136	2,052,488	5,881,624
All other cattle	3,592,779	3,153,462	6,746,241
Total horned cattle	7,421,915	5,205,950	12,627,865
Sheep	5,026,392	15,076,997	20,103,389
Goats	979,104	572,951	1,552,055
Hogs	2,551,973	4,443,279	6,995,252
Buffaloes	847	73,243	74,090

ITALY

The "*Annali di Agricoltura*" for 1879, No. 20, gives the number of cattle, sheep, goats, and hogs in Italy in 1876. The horses and mules are supplied from a special work on the "*Censimento Generale dei Cavalli e dei Muli*," made on the 10th of January, 1876. We shall compare these figures with those of the previous enumerations made for horses and mules in 1871 and for other animals in 1874:

	1871	1876
Horses	476,215	657,544
Mules	219,456	293,868
	1874	
Cows	1,380,380	1,604,127
Cattle of all kinds	3,489,125	3,491,560
Sheep	6,977,104	6,704,569
Goats	1,688,748	1,681,542
Hogs	1,574,582	1,563,573

SPAIN AND PORTUGAL

In these countries no recent enumerations have been made, and we therefore give the last official figures as compiled in the "*Statistique Internationale de l'Agriculture*," covering the year 1865 for Spain and 1870 for Portugal. Dr. Neumann-Spallart uses these figures as the average for the years 1865 to 1877:

	Spain 1865	Portugal 1870
Horses	680,373	79,716
Mules	1,021,512	50,690
Asses	1,298,334	137,950
Cows	.....	162,538
Cattle of all kinds	2,967,303	520,474
Sheep	22,468,969	2,706,777
Goats	4,531,228	936,869
Hogs	4,351,736	776,868

SCANDINAVIA

From the "*Statistisk Tidskrift*" of Sweden for 1880, the "*Annuaire Statistique de la Norvège*" for 1879, and the "*Sammendrag af Statistiske Oplysninger Nv. 8, Danmarks*

Statistik," we have the statistics of live stock in Sweden, Norway, and Denmark for the years 1877, 1875, and 1876, respectively:

	Sweden, 1877	Norway, 1875	Denmark, 1876
Horses	458,977	151,903	352,262
Cows	1,356,576	741,594	289,002
Oxen	290,831	.....	.....
Bulls	45,335	.....	.....
Calves	469,895	.....	.....
Cattle, other than cows	806,061	275,001	450,319
Cattle of all kinds	2,162,637	1,016,617	1,348,321
Sheep	1,534,861	1,686,306	1,719,249
Goats	116,813	322,861	.....
Hogs	425,718	101,020	503,667
Reindeer	.....	96,567	.....

HOLLAND, BELGIUM AND SWITZERLAND

We group these three small countries and give the latest accessible figures. Those for Holland are from the British "Statistical Abstract of Foreign Countries," those for Belgium from "*L'Agriculture Belge*" for 1878, and those for Switzerland are from the Italian "*Annali di Agricoltura*" for 1879, No. 20:

	Holland, 1876	Belgium, 1866	Switzerland, 1876
Horses	267,859	283,163	100,935
Mules	.....	.....	3,145
Mules and asses	.....	11,849	.....
Cows	914,840	738,732	593,000
Cattle, other than cows	524,385	503,713	443,000
All horned cattle	1,439,225	1,242,445	1,036,000
			1868
Sheep	891,090	586,097	580,000
Goats	149,509	197,138	.....
Hogs	352,207	632,301	2,000,000

GREECE AND ROUMANIA

The number of domestic animals in Greece in 1875 is given by M. Alexandre Tombasis in his work, entitled "*La Grèce Sous le Point de Vue Agricole.*" For Roumania the enumeration of 1873 is taken as published in the "*Statistique Internationale de l'Agriculture:*"

	Greece, 1875	Roumania, 1873
Horses	97,176	426,859
Mules	45,440	606
Asses	97,395	6,128
Cows	.....	555,060
Oxen	.....	835,735
Bulls	.....	24,865
Cattle of all kinds	279,445	1,812,786
Sheep	2,291,917	4,786,317
Goats	1,836,628	194,188
Hogs	179,662	836,944
Buffaloes	.....	15,191

We thus have, with the exception of Turkey, from which no statistics can be obtained, the number of animals of these classes in each of the countries of Europe at the latest date for which any official data or any reliable estimates exist.

For the rest of the old world, with the exception of southern Africa, Mauritius, and Ceylon, all information of this character is wholly wanting.

CEYLON

"The Statistical Abstract for the British Colonial Possessions" gives the number of horses, cattle, and sheep in Ceylon each year from 1871 to 1878. The first and last of these years may be thus compared:

	1871	1878
Horses	6,733	4,196
Cattle	996,729	889,637
Sheep	67,664	73,226

AFRICA

On the same authority we have the following figures for the other three regions mentioned above:

	Cape of Good Hope, 1875	Natal, 1878	Mauritius, 1874
Horses	241,342	21,375	18,900
Cattle	1,329,445	400,900	30,000
Sheep	11,279,743	432,660	28,000
Hogs	132,373	13,874	30,000

AUSTRALASIA

The statistics of live stock in each of these thriving colonies is published for a long series of years terminating with 1878. It will be sufficient to take the number for all of them combined, comparing the years 1870 and 1878:

	1870	1878
Horses	797,800	1,009,878
Cattle	4,712,918	7,402,659
Sheep	51,294,241	61,066,100
Hogs	694,848	815,110

CANADA

Turning next to America, we derive the following figures from the last census of the Dominion of Canada for 1871:

	Quebec and Ontario.	Total Dominion.
Horses	742,378	862,074
Cattle	2,186,636	2,687,274
Sheep	2,522,714	3,302,873
Hogs	1,246,116	1,418,597

NEWFOUNDLAND

For Newfoundland the years 1869 and 1875 can be compared:

	1869	1875
Horses	3,764	4,057
Cattle	14,726	13,938
Sheep	23,044	28,766
Hogs	6,417	.....

JAMAICA, 1869

Horses	74,157	Cattle	121,643
Sheep	21,761	Hogs	9,086

The two last are from the "Colonial Statistical Abstract."

SOUTH AMERICA

The only countries of South America for which any statistical data exist on the subject of live stock are Uruguay, the Argentine Republic, and Chili. For the first of these we have a recent official publication, "*Datos y Cuadros Estadisticos Cuaderno*," No. 10, prepared by Señor A. Vaillant. For the Argentine Republic we can only adopt the estimates of Richard Napp, as published in his work, "*Die Argentinische Republik*," 1876, which are partly official, but only come down to 1874. For Chili Señor Vaillant has recently estimated the number of cattle and

sheep. (See *Mark Lane Express*, June 14, 1880.) The number of horses in Chili in 1866, as reported by the commission of the Santiago exposition of 1869, was 241,993, which M. Edouard Sève, in 1876, estimated to be then doubled. (*"Le Chili tel qu'il est,"* p. 392.)

Combining the results as obtained from these various sources, we have:

	Uruguay, 1878	Argentine Republic, 1874	Chili, 1880
Horses	875,044	.....	484,000
Mules	8,413	.....	.....
Asses	12,415	.....	.....
Cattle	6,092,488	13,337,862	1,528,003
Sheep	12,189,511	57,501,261	2,344,505
Goats	13,350	.....	.....
Hogs	68,911	343,156	.....

THE UNITED STATES

9 |The annual report of the department of agriculture for the year ending June 30, 1879, not yet issued, will contain the following figures as to the number of farm animals in the United States on the 1st of January, 1880, which we place in juxtaposition with the corresponding figures for the year previous, as published in the report for 1877–8:

	January, 1879	January, 1880
Horses	10,938,700	11,201,800
Mules	1,713,100	1,729,500
Milch cows	11,826,400	12,027,000
Cattle, other than cows	21,408,100	21,231,000
Total horned cattle	33,234,500	33,258,000
Sheep	38,123,800	40,765,900
Hogs	34,766,100	34,034,100

The several foregoing exhibits exhaust all the resources of information known to exist on this subject, and while there still remain vast areas from which no reports have been made, and where the number of animals, though large, can perhaps never be known, still the above figures will form a valuable working basis from which the total number of each species on the globe may be estimated.

In order to present this general view more clearly, THE TIMES gives the following *résumé* by countries of the four principal groups occurring in nearly all the above reports—viz., horses, horned cattle, sheep, and hogs. The figures are always for the latest year reported:

Countries	Horses	Horned cattle	Sheep	Hogs
Great Britain	2,347,845	5,912,046	26,621,724	2,000,722
Ireland	571,803	3,921,026	3,561,361	849,046
Total United Kingdom	2,919,648	9,833,072	30,183,085	2,849,768
France	2,852,419	11,351,220	23,902,077	5,801,002
Germany	3,352,231	15,776,702	24,999,406	7,124,088
Russia	16,160,000	23,601,000	48,585,000	10,332,000
Austro-Hungary	3,543,443	12,627,865	20,103,389	6,995,252
Italy	657,544	3,491,560	6,704,569	1,563,573
Spain	680,373	2,767,303	22,468,969	4,351,736
Portugal	79,716	520,474	2,706,777	716,868
Sweden	458,977	2,162,637	1,534,461	425,718
Norway	151,905	1,016,617	1,686,306	101,020
Denmark	352,262	1,348,321	1,719,249	503,667
Holland	267,859	1,439,225	891,090	352,207
Belgium	283,163	1,242,445	586,097	632,301
Switzerland	100,935	1,036,000	580,000	2,000,000
Roumania	426,859	1,812,786	4,786,317	836,944
Greece	97,176	279,445	2,291,917	179,662
Total Europe	32,384,508	90,506,672	193,728,709	44,825,806
Ceylon	4,196	889,637	73,226	.....
Cape of Good Hope	241,342	1,329,445	11,279,743	132,373
Natal	21,375	400,900	432,660	13,874
Mauritius	18,969	30,000	28,000	30,318
New South Wales	336,468	2,771,583	23,967,053	220,320
Victoria	210,105	1,184,843	9,379,276	177,373
South Australia	121,553	251,802	9,377,812	103,422
Western Australia	32,801	56,158	869,325	16,762
Queensland	147,076	2,433,567	5,564,465	50,301
Tasmania	24,107	126,276	1,838,831	39,595
New Zealand	137,768	578,430	13,069,338	207,337
British North American provinces	866,129	2,701,212	3,331,639	1,418,597
Jamaica	74,157	121,643	21,761	9,086
Uruguay	875,044	6,092,488	12,189,511	68,911
Argentine Republic	.....	13,337,862	57,501,261	343,156
Chili	483,980	1,528,003	2,344,505	.....
United States	11,201,806	33,258,000	40,765,900	34,034,100
Grand total	47,181,384	157,598,521	382,763,015	81,691,331

We thus have as the total number of these four animals in all the countries enumerated, 669,234,251.

Collating, without regard to countries, the remaining animals, of which the statistics are less complete, we have:

	Number of head
Mules	3,474,391
Asses	2,217,166
Mules and asses (not distinguished)	11,849
Goats	15,704,911
Buffaloes	89,281
Reindeer	96,567
Total	21,594,165

This number added to the previous one gives 690,828,416, as the total number of domestic farm animals which it is at present possible to obtain from the most recent reliable data.

COWS

The importance which cows assume for the dairy interest justifies a remark respecting them. The whole number of cows reported from the above countries is 40,968,928, but many of these countries fail to distinguish them from other horned cattle. The number of cattle in countries not distinguishing cows is 60,681,597, which is 38.5 per cent. of the whole number of cattle. Assuming the proportion of cows to total cattle to be the same in countries not reporting them as in others, the total number of cows in all the countries would be 66,616,462.

COMPARISONS WITH POPULATION

According to Baron Kolb ("*Handbuch der Vergleichenden Statistik*") the population at the beginning of the year 1879 of the same countries for which the statistics of live stock

are given above amounted in the aggregate to 366,100,000. Comparing this with the figure obtained as the number of all the animals reported in these countries, we have as a result, 1,887 animals to each 1,000 population. The same comparison for each species of animals gives for each 1,000 human population 130 horses, 430 horned cattle, 1,046 sheep, 224 hogs, and 59 of the remaining kinds of animal. The last of these figures is of course too small, from the number of populous countries from which there are no returns. In the cases of horses and hogs, the former lacking in the Argentine Republic and the latter in Chili and Ceylon, the population of these countries is deducted from the basis on which the computation is made.

We therefore perceive that the only domestic animal that exceeds the human race in numbers, in the more or less civilized countries of the globe, is the sheep. That this proportion could not hold good for the rest of the world is evident from the fact that savages and barbarians possess domestic animals only to a limited extent, or not at all. Mr. Robert P. Porter ("Bradstreet," June 26, 1880) has estimated the total number of sheep in the world at 584,750,000. To obtain this figure he has assigned to Asia 175,000,000, and to Northern Africa 20,000,000, and while for most countries he gives figures larger than the official ones, he has reduced South America and Mexico (58,000,000) nearly to the best estimates for the Argentine Republic alone in 1874, which is doubtless an error. These 195,000,000 for Asia and Northern Africa amount to about 33 per cent. of his estimate for the world, yet this, if reliable for sheep, could furnish no criterion for the other animals.

The present population of the globe, according to the latest number (No. 6) of Behm & Wagner's "*Bevölkerung der Erde*" is 1,456,000,000, and it would not probably be very wide of the truth to place the total number of all classes of domestic farm animals at the same figure.

January 25, 1881—Ætat. 39.

109. Evolution of the Chemical Elements

History.—Rough draft written February 18 to March 29, 1879. The paper was read before the Philosophical Society of Washington on March 29th. It was rewritten in its present form June 9–16, 1879, and sent to the *Popular Science Monthly*. There it lay in the mass of surplus matter for more than a year, but it was not consigned to the waste basket nor returned to me as I had provided and expected, and when I met Dr. E. L. Youmans in Boston on August 30, 1880, to confer with him on the prospects of the Appleton Company publishing my *Dynamic Sociology*, he apologized for the delay of this article and assured me that it would soon see the light.

The Popular Science Monthly, New York, Vol. XVIII, No. 4, February, 1881, pp. 526–539.

MUCH may be said in favor of the hypothesis of the progressive development of all the stable forms of matter by a true process of evolution from antecedent states. Indeed, in the higher forms of matter,

in those which we know to be of composite constitution, this process is more or less thoroughly understood. Most of the objects which surround us, whether organic or inorganic, are known to consist of a great number of elementary parts of the same size and form which are aggregated in definite ways to form the general mass which each such object presents. These particles, which are alike for all parts of the same object or species of object, are unlike for different objects. Each object is an aggregate of elements of the same species, and these elements are the *units of aggregation*. All aggregates which have been thus far resolved into these units have confirmed this law. What is known, however, of the higher aggregates of matter is sufficient to establish another law, viz., that such aggregates are the result of the successive recompounding of units of aggregation of descending orders. The units of aggregation of aggregates of the higher orders are compounds of lower units. This is physically proved to be true of all aggregates of known composition.

In biology we have the individuals of various orders, both animal and vegetable, in which the lower forms are taken up bodily and made to enter as integral units into the higher forms. Not only are all animals and plants compounded of innumerable cells as ultimate biological units, but the earlier forms, which are aggregations of cells, are repeated as units in the higher forms. The tape-worm is an animal of the third order, the cell being taken as the first, but its segments are so feebly integrated that they possess all the essential characteristics of perfect animals. In the higher *Annulosa*, the integration is more complete, but the composite character is still evident. In the *Vertebrata*, the process of coördination has proceeded so far that only the closest | embryological study can reveal 527
their composite nature. On the other hand, corals as well as many protists, such as the *Labyrinthuleæ*, coexist with so small a degree of integration that the parts

are considered as distinct individuals, although clearly dependent on one another.

The vegetable kingdom illustrates still more clearly the manner in which the aggregates are compounded. We have plants, like *Caulerpa*, which, while the form would lead us to expect a considerable degree of organization, consist in reality of a simple aggregation of homogeneous cells. In higher plants, the leaf forms a new order of organization, and constitutes the morphological individual or unit. In trees, the process of compounding has gone so far that, considered as individuals, they may reach the hundredth degree.

If we contemplate the mineral kingdom, we are again shown the same truth. The various recognized minerals are not generally found to be composed directly of the simple chemical compounds into which they may be resolved, but consist of compounds of different orders into which the simpler compounds enter as units of composition. Thus feldspar contains silica, alumina, peroxide of iron, lime, soda, potash, magnesia, water, etc., as units of composition, none of which is supposed to exist in the mineral in any simpler state, and all of which are already more or less complex chemical compounds. Moreover, two or more of these minerals thus formed often again combine as new units to form others of still higher organization.

When we consider the facts which chemistry furnishes, we see the same law still operating in great simplicity. In many of the binary, ternary, and higher compounds, theory requires us to assume that the substances entering into them do so in their integral state, and are not first decomposed into their primary elements and then reorganized into the new compound. The hydrated oxide of potassium, for example, is not written KH_2O_2, but KO,H_2O, in which both the immediate constituents are regarded as maintaining their composite state and entering bodily into the new compound. The entire series of "compound radicles" requires the same supposition and illustrates the same

general principle. Cyanogen (CN), ammonium (NH_4), methyl (CH_3), ethyl (C_2H_5), and the rest are now held to constitute integral units in the formation of the hydrides, alcohols, and acids.

So far, then, as induction can be depended upon, we find that it is a universal law of the aggregation of matter that each new aggregate may become a unit for the formation of aggregates of higher orders. Does this law cease with the so-called chemical elements, or are these themselves the products of molecular aggregation?

Without discussing the old and apparently insolvable problem of the divisibility of matter, it may be remarked that while the known facts of science are entirely satisfied with the hypothesis of an ultimate, finite unit of matter, of which all perceptible objects are but | aggregations, 528
at the same time they do not conflict with such a modification of that hypothesis as assumes the actual magnitude of these units so far reduced as to be practically infinitesimal. They only declare—but this they do in the most emphatic manner—that this reduction must not be so far continued as to make the ultimate atom equal to zero, in the sense of absolute nullity.

On this view, which is by no means a new one, of the ultimate constitution of matter, the units of the so-called chemical elements, even of those having the smallest atomic weights, may themselves be of a relatively high order of aggregation or organization, below which many degrees may exist in which the molecules are too minute to form bodies which the senses can in any manner detect. The interstellar ether may be explained as constituting one of the highest of these degrees, yet not high enough to form matter such as to be visibly subject to the law of gravitation. The nebulæ present the evidence of the lowest form of such so-called "ponderable matter," and these may be supposed to be the result of a gradual development resulting from the successive recompounding of the molecular aggregates, until they finally acquire a certain influence over one another

and tend to molar aggregation, forming the nebular masses. At the outset these aggregates may be supposed to be entirely homogeneous, consisting wholly of molecules of the same degree of aggregation, but they soon differentiate into several distinct kinds of matter. These are the gases which the spectroscope reveals in some of the nebulæ. They have molecules of low atomic weights and remain gaseous at all temperatures artificially producible. This process of evolution, which is the same which we have seen to go on in all the well-known forms of matter, would seem also to continue throughout the history of the nebulæ and the organization of resultant planetary systems, developing many additional forms of matter, likewise characterized by the increasing mass of their molecules.

What the properties of those molecular aggregates may be whose activities can not be revealed to sense, is of course unknown. Conjecture even as to the probable number of degrees of aggregation from the ultimate atom to the supposed atom of hydrogen would of course be idle. But that such forms exist far down upon this inaccessible plane, having definite shapes, sizes, and activities, we are strongly led to assume, both by the facts already stated and by others presently to be set forth.

Passing over these lower stages, therefore, whose study belongs to the future of human science, or to possible beings endowed with finer faculties, and which may be said to belong to the domain of transcendental chemistry, we finally arrive at a class of aggregates of great stability, but which, though still so minute that they can only be perceived when accumulated into masses, have nevertheless been studied in their free state by means of the various phenomena to
529 | which they give rise, either in their natural condition, or, as is usually the case, under certain artificial conditions to which the ingenuity of man has learned to subject them. As these aggregates are the lowest which can be perceived, they have been denominated elements, and are by some supposed to constitute the ultimate units

of matter. But, independently of certain direct evidence against this view, it is far more consistent with what is now known of matter, and with the laws of thought, to regard them as the first or lowest stages of aggregation whose activities are capable of appealing, either directly or indirectly, to our senses. It is really no more probable that the so-called elements are the lowest subdivisions of matter than that the remotest stars visible are actually at the confines of the universe.

That these elements are capable of manifesting themselves to sense is the sole reason of our recognizing their existence; and the history of their discovery, by which their number has been so greatly increased, shows that their modes of manifestation are often so subtle as to escape all but the most thorough methods of detection. Many of these elements now universally recognized remained for a long time wholly unsuspected, and these then belonged to the great class of unknown aggregates. This interesting chapter in the history of science should suffice to teach us that below the known of to-day there lies a wide belt of the knowable unknown, and that other and still lower orders of aggregates will doubtless yet be induced to reveal their existence.

A reason for regarding these elementary substances as ultimate units has been supposed to be found in their great stability, which causes them to behave as if such were the case.

While there is one possible exception to this in the case of oxygen and the peculiar phenomena of ozone and antozone, it is indeed true, so far as known, of all the remaining elements, that they have thus far resisted all attempts to decompose them. This, however, aside from the possibility of doing so still, is really no evidence of their absolutely elementary character, but only indicates what the whole theory of evolution would admit, if not require, that all aggregates which could possess the properties requisite for the composition of such masses as are capable of affecting the senses, or of so affecting other masses as to make them-

selves known to the human intellect, must possess a degree of inherent stability sufficient to resist all human efforts to disintegrate them. While, therefore, it is very probable that, just as the alkalies and alkaline earths, which, at the beginning of the present century, were regarded as elementary, have yielded to the galvanic battery and proved to be composite, so a few more of those now classed as elements will at no distant day be similarly decomposed by the higher appliances yet to be devised; it is nevertheless entirely consonant with the view of the constitution of matter here maintained, that there shall remain upon the plane
530 of human investigation a | greater or less number of wholly undecomposable aggregates, serving as the primary basis of all tangible substances.

It must be expected, however, that these elements will possess all degrees of capacity for manifesting their presence, and that while some will stand out boldly, cohere in vast masses, like iron, for example, and in various ways render themselves obvious and obtrusive, others will be ever hugging the confines of the imperceptible, and, like ozone, will perpetually evade the full scrutiny of science. To this latter class also belongs the substance which emits the green ray of the solar spectrum, which has already led eminent chemists to conjecture that it may be of simpler constitution than any recognized element, if not the primary form of matter.

Setting out with the elements, regarded as aggregates of a comparatively high order and stable organization, but differing from one another in form, size, and molecular activities, as widely as the masses they form differ in properties, the problem of the formation of the higher orders of aggregates becomes comparatively simple. We find ourselves already in the domain of experimental science where the more or less completely demonstrated laws of chemistry and molecular physics lead us up to the formation of the various inorganic and organic forms of matter. The constitution of the various substances found upon the earth

is readily determined by decomposing them and weighing their constituents. The precise conditions, however, which have resulted in their formation as we find them and brought about the existing state of things in the universe, are not so easily determined, and for this purpose a further extension of the general law of material aggregation is required.

The study of the earth's crust clearly indicates that very different conditions have existed upon it in the remote past from those which we now find. The facts as a whole prove beyond a doubt that our globe has once been in a state both of greater or less liquidity and also of great heat, and that, as its surface has cooled down, the solid parts, to which alone we have access, have been formed, though to what depth these extend we are still ignorant. But, notwithstanding certain doubts which have from time to time been cast upon it, the theory which was very early advanced as most in harmony with the probable history of the planet, and according to which the cooling process has not yet reached the great interior, which is therefore still in a heated and molten condition, still furnishes, perhaps, the most rational explanation yet made of the phenomena which the earth presents, and also best satisfies the *a priori* requirements.

It is now generally believed that the present condition of our earth, and also that of the entire solar system, has been the result of a cosmical process of development by which its matter, unchanged in quantity, has been slowly condensed from a diffused nebulous state, occupying enormously increased space—a condition analogous to, if not identical with, that which is now presented by a large number of irresolvable nebulæ whose spectra show 531 them to be composed of gaseous matter in an incandescent state. This gaseous or nebulous condition, though exceedingly rare relatively to the solid forms of matter familiar to us, is nevertheless a state of a high degree of aggregation as compared with the forms of matter by which it is surrounded and with its wholly unaggregated state. Before the opera-

tions which may be designated as molar can commence, a degree of aggregation must be reached far exceeding that which exists in those molecules which are the vehicles of luminiferous radiations. The particles constituting the ethereal matter of interstellar space must be supposed to be so minute and relatively far separated as not to exert any appreciable influence upon one another tending to produce molar motion or organization; a condition which is explained on the same grounds as the fact that one system in space exerts no appreciable influence upon another system.

If the so-called chemical elements are simply so many stable molecular aggregates, whose differences are due to different modes and degrees of aggregation, then the gases of our earth are simply the most diffused state in which masses of these aggregates can be obtained. A gas is a diffused mass of homogeneous molecules, and this definition is as true of the compound gases, steam, carbonic acid, or vapor of alcohol, as it is of the simple ones, such as hydrogen, nitrogen, or vapor of mercury. It might, then, be naturally supposed that the nebulæ would contain a number of such gases, and as it is scarcely to be presumed that all the modes of forming stable aggregates are represented on our planet, so, in addition to some of those found here, it is reasonable to expect that nebulæ will contain some not known to us. In so far as the spectroscope—to which, indeed, we owe all our positive evidence of the existence of true nebulæ—is able to inform us, this view is confirmed. Two of our commonest gases, hydrogen and nitrogen, have been identified in nebulæ, while a third has been discovered which has not yet been identified with any known element.

Every modification of the nebular hypothesis yet put forth has been compelled to assume that the original nebulous mass must be in an incandescent state. Certain it is that all visible nebulæ are self-luminous. But this is a condition of their visibility. It can not be known how

many may exist which have not yet reached this state, and are, therefore, invisible. It does not seem necessary to suppose that the contraction of a nebulous mass is either due to, or requires, a high temperature. No reason exists why cold particles may not become collected into a diffused mass. The inherent motions of these particles are not increased or diminished. But, these motions remaining the same, their circuits of motion are reduced, the frequency of contact is increased, and heat and light are evolved from the friction. The tendency of all matter under the law of gravitation, considered as an unexplained fact, is toward concentration. The evolution of heat is rather 532
the check put upon this tendency, and, in so far as it exerts any influence, it exerts it in a direction the reverse of gravitation. There is a perpetual and rhythmic antagonism between the forces of integration and disintegration. When for any reason the former acquires an impetus which carries it to great lengths, it is resisted with increasing violence by the antithetical force evolving great heat, and eventually restoring the normal equilibrium. It seems altogether probable, therefore, that in the process of contraction of a nebulous mass, and its resolution into a system of worlds, the amount of heat radiated is in the end equal to the amount produced by condensation, which disposes entirely of the supposition that there must exist an incandescent nebula at the outset. The so-called "cooling off" is only apparent, and, while at times the amount of heat may be diminished, at other times it will be correspondingly increased. If the radiation of heat from the surface of a body into space tends to cool it off, so does the constant diminution of its volume without loss of mass tend to heat it, and throughout its career these two influences must antagonize each other. It is only after the limit to possible contraction, due to the nature of matter itself, begins to be reached that the amount of radiation of heat comes greatly to exceed the amount of its generation, and that the body actually begins to cool off.

During the greater part of the history of an evolving system, the central mass must possess an enormously high temperature. This is required by chemistry as well as by physics. Throughout nearly the whole of this period, all the matter of the system must exist in the form of gas. But there exist in our globe many substances whose existence in the gaseous state presupposes great heat. The degree of heat required to volatilize the metals is immense, and there are certain other substances, such as silicon, for which still greater temperatures are demanded. It would, however, be a violent assumption to suppose that the parent nebulæ, out of which the solar system was formed, contained from the outset in this diffused state all the substances which are found on the earth. It is much more reasonable, and our hypothesis permits us, to assume that these substances, requiring so great heat to liquefy and volatilize them, have been *created*, i. e., *developed*, during the progress of the formation of the system out of materials already existing in other forms and states of aggregation. On the supposition that during the earlier part, and perhaps during all but the very latest period, of this process the temperature of the nascent system was increasing, it is reasonable to assume that the intense heat would cause the breaking up of some of the molecular aggregates which were capable of maintaining the gaseous form at low temperatures, and would at the same time cause the formation of new aggregates only capable of maintaining that form under the high temperatures to which they were subjected at the time of
533 their formation, many of which, nevertheless, would prove sufficiently stable to preserve the new form of aggregation after the temperature should go down, and, instead of reverting to their former condition on the cooling of the system, would assume successively the liquid and the solid states, and become constituent parts of and distinct substances in the cooled-off planets.

This theory of the origin of all those elementary terrestrial substances which require great heat to convert them

into gas is supported by some facts. In the first place, none of the gases of these substances have been discovered in any of the nebulæ. The only two terrestrial substances, thus far determined with any certainty, are hydrogen and nitrogen. The latter of these exists in a free state in the earth's atmosphere, forming about four fifths of its volume and three fourths of its weight. The former does not exist in a free state in the atmosphere, in consequence of its strong affinity for oxygen, which is present there in excess, and whose union with it forms the waters of the globe. Both of these substances are gases at all temperatures producible by artificial means, and have only very recently been made to assume the liquid and solid states by the use of extraordinary devices. The other definite line which the spectrum of certain nebulæ presents is near to that of barium, but is conceded not to be the barium-line. It is, therefore, an unknown substance, and nothing can be said of its properties. Its proximity to the barium-line in the spectrum can not certainly be taken to indicate any special resemblance to that metal; and it is probably a gas at low temperatures, like hydrogen and nitrogen.

In the second place, as to these two last-named substances, one of them, hydrogen, is present in nearly or quite all the self-luminous bodies whose spectra have been observed, where it seems to occupy a position far out in the upper atmosphere. As to nitrogen, its presence in such bodies is doubtful, so far as the spectroscope is able to inform us; but, as it exists in such quantities in the earth's atmosphere, the belief is strong, especially among those who accept the nebular hypothesis, that the failure to discover it there is due to our imperfect methods, or to our ignorance of the manner in which the phenomena of the spectroscope are to be interpreted. The recent triumph of science, in the discovery of oxygen in the sun, serves to show how easy it is to overlook phenomena all the while perceptible, and gives great hope that not only nitrogen, but many other substances, will yet be found there, which have hitherto escaped

observation. The fact that an element exists in the earth may not be proof that it must exist in the sun, even on the assumption that the sun is the parent of all the planets, but it is certainly strong presumptive evidence that it is also there. It is, however, much stronger proof that it existed in the general mass, as late at least as when the earth was formed out of it, and therefore in the original nebulæ. Those
534 | evolutionists alone who are ready to accept the view here advanced of the derivation of the heavier elements from the lighter ones, in the course of the development of the system, can escape this conclusion by supposing that the substance in question was created in the planet after its separation from the central mass. But this assumption would not be required in the case of nitrogen, which remains a gas at high temperatures, and which actually exists in the nebulæ. The fact that it can be detected in the nebulæ, and not in the sun, although it doubtless abounds in both, may be accounted for by remembering that the spectrum of a nebula belongs to a different class from that of the sun, the former consisting of bright lines on a dark ground, indicating a luminous gas; while the latter consists of dark lines on a bright ground, indicating a body having an incandescent solid or liquid interior, the rays of which pass through a cooler gaseous atmosphere. Now, this antithesis in the constitution of the two bodies may explain why certain elements existing in both may be capable of spectroscopic determination only in one, owing to peculiar conditions supplied by the special nature of the substances themselves; for it is by no means probable that the spectroscope gives us an account of all the substances existing in the bodies examined by it.

While, therefore, there is nothing in the facts thus far discovered which is opposed to the theory that the terrestrial substances having high melting and volatilizing points have been developed out of substances which are gaseous at lower temperatures in the course of the evolution of planetary systems, these facts, so far as they bear at all

upon the problem, are decidedly favorable to such an hypothesis. We certainly find such substances in our earth and in the intensely heated bodies of space, as well as in such meteoric aggregates as from time to time reach our planet, and we have not yet found any such in existing nebulæ. If the latter be conceived as gaseous, and the solar system as only a developed state of one of them, either some such hypothesis must be brought forward to explain the existence of such substances in the earth, or the original mass must be supposed to possess a sufficient degree of heat to maintain them in a gaseous form, which would be enormous, and, independently of the present theory of the origin of the nebulæ, altogether improbable. Of course, upon the view here taken, it would be wholly inadmissible. Prior to the stage in the history of a nebula at which the degree of molar aggregation is sufficient to occasion a great amount of friction among the particles, the temperature of the primary molecular aggregates must be nearly that of space, and it can rise only as increase of density and molar motion increases that friction and converts material motion into ethereal vibration. Nebulæ must therefore possess a long history, of which neither the telescope nor the spectroscope can furnish any record—the pre-luminous period—in which, of course, no gases can exist except those, like hydrogen and nitrogen, which maintain their gaseous form | under extremely low tem- 535
perature. And it may be supposed that during this period other gases may exist associated with these, which, however, unlike them, are unable to sustain the successively higher and higher temperatures which the nebula acquires in its process of condensation and organization into a system, and at certain stages of this process are dissociated and resolved into aggregates of a different constitution, suited to these temperatures. Some of these latter new aggregates would naturally assume the liquid and solid forms at temperatures still high as compared with those to which we are accustomed, and constitute in the cooled-off

crust of the planets the various metals and metalloids. In this manner we should have no difficulty in accounting for the existence of all the elements found on the earth, even if it were positively known that only the lighter gases were present in the parent nebulæ.

The recognized elementary substances, presenting so many different qualities, vary greatly in their so-called "atomic weights." This means simply that their molecules vary greatly in mass. The hydrogen molecule is the least known, and is therefore taken as the standard. Compared with this as unity, we find that the molecule of oxygen contains 16 times as much matter, that of carbon contains 12, that of nitrogen 14, and that of chlorine 35½ times as much. But these, instead of representing large equivalents, are, when compared with most of the metals, very small. One molecule of mercury contains two hundred times as much matter as one of hydrogen. The atomic weight of gold is 197, of platinum 197.4, of lead 207, and of bismuth 208; while the thorium equivalent, which was quadrupled in the new system, is now put at 231.4, being the largest of all the elementary units. Whether hydrogen, carbon, nitrogen, oxygen, or any of the other abundant elements having small molecules have entered into the composition of these heavy substances, is a legitimate question. The fact that these molecules are stable, whether combined or uncombined, is favorable to this view, although there may exist, as component units of the molecules of the metals, many equally stable aggregates which no human power can dissociate from their present combinations. But, if known elements were employed as components of other known elements having larger molecules, the very fact that they are elements, i. e., that we are unable to decompose them, would render it impossible to know that such was the case. Think how many hydrogen, nitrogen, or oxygen molecules might enter into the system that constitutes the unit of bismuth or of gold!

Now, it is a remarkable fact that those elements which

have very high condensing points, i. e., which assume the liquid (or solid) form at very high temperatures, generally have large combining numbers, that is, large molecules; while those having low condensing points and which are gaseous at ordinary temperatures, as a rule have small combining numbers, or small molecules. To this, carbon on the one hand, | and mercury on the other, form, it is true, notable exceptions; nevertheless, the bulk of the facts 536 sustain this law, and indicate that the genesis of those elements which we know only as solids or liquids, and which we have supposed to have taken place during the fiery ordeal through which the solar system has had to pass, is rather a process of *integration* than of subdivision, since they have much larger molecules than the gases that exist in the nebulæ, and out of which we have supposed them to be formed.

We have seen that matter, in its cosmical history, as enacted in the development of a planetary system, assumes a great variety of forms, and resolves itself into numerous specifically distinct molecular aggregates. The different substances which we know on our planet are the result of the cohesion into homogeneous masses of these different aggregates, all the constituent units of any one of these masses consisting of the same *species* of molecular aggregate. We saw reason to suppose that, at an early period in the development of the solar system (and we may infer the same for all systems), the number of distinct substances was small, and that these substances were gaseous at very low temperatures. The two abundant gases, nitrogen and hydrogen, exist in the irresolvable gaseous nebulæ, and these, doubtless, went far to constitute the original substance of our infant system. These gases, though differing greatly from each other in their atomic weights, nevertheless have small molecules compared with those of most substances now found in the earth, and which are, for the most part, either solid or liquid at life-supporting temperatures. There has,

therefore, been upon the whole *increase of mass* among the molecules of substances later developed.

When we rise to the point of view which removes all distinction between elements and compounds, except the subjective one that in the former we do not know and can not prove their composition, while in the latter we can do this in so far as to resolve them into the former, we can make the further generalization that along with this increase of mass there has gone *decrease of stability* in such molecules. We are of course unable to predicate this, except inferentially, of the elements which we can not decompose, although these, doubtless, vary greatly in their relative stability, and, as before remarked, some substances which had been supposed to be elementary have already been reduced to simpler forms, and others may still be so reduced. Moreover, those which have thus yielded possess large molecules (counting that of the compound), and this should serve as an index to future attempts of a like nature. There is, for example, little hope of resolving hydrogen or carbon into simpler elements, but the reverse of the alchemist's dream may yet be realized, and gold reduced, if not to baser, at least to simpler materials.

537 All the known chemical compounds must be supposed to have been | developed within relatively quite recent periods. The great heat that has prevailed throughout the greater part of the history of the solar system, and which, indeed, still prevails in its nucleus, the sun, which is still $99\frac{13}{15}$ (99.866) per cent. of the entire mass of the system, or practically the whole of it, has prevented the formation of any of the substances which we know to be composite. It is only in the comparatively minute masses which have been accidentally separated from the rest, and which, in consequence of their diminutive size, have earlier reached the point at which the radiation exceeds the generation of heat, that conditions have been produced under which these comparatively unstable substances, such as water, carbonic dioxide, and the other oxides comprising the earth's crust,

could exist. In proportion as the degree of heat diminished, the capacity for more and more unstable substances increased. The earliest compounds were those in which silicon, potassium, sodium, magnesium, etc., combine with oxygen, several of which were, from their great stability, long regarded as elementary. Then came a variety of acids, alkalies, and salts, together with compounds of the metals. Later, as the temperature still further lowered, the oxygen was enabled to seize the hydrogen and form the gaseous protoxide, steam, which at a still later period, when the temperature of the earth's surface fell below 100° Centigrade, condensed into water. Long prior to this, carbonic acid had been formed, and, doubtless, constituted at that time fully one half of the earth's atmosphere. The vast amount of free carbon now existing in the earth, and, still more, that which is fixed in the chalk and limestone formations, all of which must have formerly existed in the atmosphere in the form of carbonic-acid gas, indicates that the above estimate is probably far too low.

All the compounds thus far referred to, and all others having a certain degree of stability, must have been first formed at a period of considerable heat, the dissociation point of all compounds having been estimated at 6,000° Centigrade; although this, doubtless, varies for different compounds as greatly as do the condensing points of different gases. But there are, besides, many compounds which are continually forming at such temperatures as now prevail on the surface of the earth, and most of these are very much more unstable than those last mentioned. The elements which chiefly enter into such compounds are oxygen, nitrogen, hydrogen, and carbon, all but the last named of which are gaseous at ordinary temperatures. The substances of this nature with which we are familiar are known as *organic compounds*, and such as we see are, in fact, the products of organized beings from the different parts of which they are obtained. But this process should not be regarded as any less cosmical than that by which the

rocks or the metals have been evolved out of primordial matter.

Time forbids the further following out of this series of steps in the development of existing forms of matter, but it will be readily perceived how, if this train of reasoning be sound, the inorganic is directly linked to the organic world, just as the imperceptible forms of matter were shown to be linked to its perceptible forms, and the elementary states to the composite states, in one continuous and unbroken chain. It remains to point out to what extent the hypothesis here advanced, of the probable genesis of the chemical elements, is found to be in harmony with the recent discoveries which Mr. J. Norman Lockyer has made by means of the spectroscope in the domain of chemistry. In endeavoring to do this in the briefest manner possible, let us reproduce the following diagram drawn up by him:

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Hottest stars,	Lines of	H+Ca+Mg
Sun,		H+Ca+Mg + Na + Fe
Cooler stars,		— — Mg + Na + Fe + Bi + Hg.
Coolest,	Fluted bands of	— — — — — —, etc.

Modified in the arrangement only to suit the present discussion, the first part of this diagram may be presented as follows:

Cooler stars.

Sun.

Hottest stars.

1	24	40	23	56	200	208
H +	Mg +	Ca +	Na +	Fe +	Hg +	Bi
1	12	20	23	28	100	208

The figures placed over the symbols are the respective atomic weights of the elements according to the new system, those placed beneath being the same according to the old system. Transposing calcium and magnesium merely for the sake of symmetry, their position being indifferent,

since both appear in the hottest stars, we find that with a single exception, that of sodium, if we take the new system, and without exception, if we take the old system, the atomic weights increase as the temperature of the body diminishes. To what extent this result may be accidental it is of course impossible to say, but, so far as it may have any scientific significance, it constitutes an interesting confirmation of the theory that the heavier elements with large molecules have been developed out of the lighter ones with small molecules during the progress of the condensation and refrigeration of the heavenly bodies, and according to which, as above pointed out, those possessing the largest equivalents would be last formed and gradually pass into the known compounds by a corresponding gradual decrease of stability, these latter to be succeeded in turn by the evolution of organic aggregates which ushered in the era of life.

Generalizing from all that has been said, we may divide the known | forms of matter into the three following classes, with the accompanying definitions: 539

1. Chemical Elements.—Substances whose molecules are composed either of those of other chemical elements of less atomic weight, or of such as are too low to be capable of molar aggregation, and therefore imperceptible to sense: formed during the progress of development of star-systems at temperatures higher than can be artificially produced, and hence too stable to be artificially dissociated.

2. Inorganic Compounds.—Substances whose molecules are composed of those of chemical elements or of other inorganic compounds of lower degrees of aggregation: formed in the later stages of the development of planets at high but artificially producible temperatures, and therefore capable of artificial decomposition; and constituting the greater part of the solid crust of cooled-off bodies, their liquid and a portion of their gaseous envelope.

3. Organic Compounds.—Substances whose highly complex and very unstable molecules are composed of

those of chemical elements, inorganic compounds, or organic compounds of lower organization: formed on the cooled surfaces of fully developed planets at life-supporting temperatures.

110. Incomplete Adaptation as Illustrated by the History of Sex in Plants[1]

History.—Written August 1–8, 1880. Read before the Biological Section of the American Association for the Advancement of Science August 27, 1880. Professor Cope was present at the reading, made some complimentary remarks, and afterwards asked me for the paper for the *American Naturalist*, of which he was then the editor, and I handed it to him in Boston.

The American Naturalist, Philadelphia, Vol. XV, No. 2, February, 1881, pp. 89–95.

THE doctrine of abrupt changes or cataclysms in nature has a remarkable survival in the still prevalent belief in perfect adaptation. As it was formerly held that organisms were purposely made for their conditions and exactly adjusted to them, so now since the law of self-adjustment has become current, it is supposed that the organism and the environment have in all cases

[1] Read before the Biological Section of the American Association for the Advancement of Science, at Boston, August 27, 1880.

reached a condition of complete correspondence. It is in virtue of this assumption that the law of cross-fertilization of plants has been called in question, and an eminent botanist once remarked to me that the slight difference between the results of Darwin's experiments under cross and under self-fertilization, amounting on an average to one-fifth of the whole, was sufficient to invalidate that law.

Nothing seems so difficult for the human mind to grasp as change through minute variations indefinitely continued. Even those who admit that this is nature's method, fail to realize it in concrete examples.

We may suppose that a given character not possessed by a given species would, as a matter of fact, be an advantage to such species if it could acquire it. We may further suppose that if for any reason the species commences to vary in the direction of acquiring that character, the benefit will be proportional to the degree of completeness with which the character is attained.| Under the law of
90 natural selection, the perfection of the character will ultimately be reached, but a very long period, to say the least, must elapse during which it is still incomplete.

Again, the conditions surrounding a species are constantly changing, usually slowly, but sometimes rapidly or suddenly. In this way the usefulness of certain characters is frequently destroyed, but the species cannot lose the character; it persists and gradually becomes atrophied or transformed into a different one. Such changes in organisms are very slow, and vast periods are passed through before they are completed.

Now, considering the changes going on at all times in the conditions under which species exist, it may often happen that the period during which adaptation is incomplete from both these causes, is greater than that during which it is complete. Indeed, as a matter of fact, the adaptation is never absolutely complete, the organism being always, as it were, behind its environment, as the tides are behind the moon.

If this be true, we ought to expect constantly to find examples of incomplete adaptation. A character which required to be complete before it could be advantageous could never be acquired by natural selection. All such characters as are acquired must be advantageous in proportion as they are complete.

Naturalists must therefore learn to regard a large proportion of the characters which they find to exist, as partial or uncompleted characters, useful to the species in proportion as they are developed, but capable of greater adaptation.

There are, moreover, two general classes of characters with respect to their usefulness and advantageousness to the species. Those of one of these classes are only useful to a certain limited degree, beyond which they may be injurious, and which only apply to particular species in their relations to definite existing conditions. Such characters may be called *special*.

The other class, which may be distinguished as *general*, apply to all organisms, and are less limited in their degrees of possible development.

Passing over the class of special characters, I propose to illustrate the principles above stated by an example in the class of general characters taken from the vegetable kingdom.

The distinction of sex is a condition advantageous to all plants, and one in the process of attaining which a large number of grada|tions are to be found. The 91
purely asexual state exists only in the lowest Protophytes, as in Saccharomyces, the Phycochromaceæ, and other unicellular forms. The simple phenomenon of conjugation or copulation seen in the Zygomycetæ and diatoms, forms the earliest step towards sexual differentiation, which is followed by the various intermediate steps represented by the pairing of active cells in Volvox, the formation of oöspores in the Confervæ and Fucaceæ, and of carpospores in the Fungi.

In the Characeæ we first find the well-marked distinction

of antheridia and carpogonia, the former furnishing in Nitella the active spermatozooids which differ immensely from the cells with which they combine. This latter feature continues to characterize all the higher Cryptogams, though in nearly all cases the organs of both sexes are borne on the same plant. The transition from the Cryptogams to the Phanerogams is effected by a primary differentiation of the spores, which in most Cryptogams are the independent asexual bodies that produce the sexually differentiated prothallium. This prothallium loses its independence and becomes the albumen of the seed; the male spores are converted into pollen grains and the antheridia into the fertilizing pollen tubes; the female spores are transformed into embryo-sacs containing corpuscles within which are the ultimate germ-cells.

In a certain sense this transition, instead of marking an advance in the process of sexual separation, constitutes a step backward, since the prothallia of Cryptogams, considered as distinct individuals, are respectively male and female, while the stamens and pistils of the Cycadaceæ and Coniferæ, the earliest Phænogams developed, though quite distinct in themselves, are both borne on the same plant. But the prothallium marks the highest development reached or possible to the Cryptogam. The Phænogam must begin from a point lower down, and in turn evolve sexually differentiated forms. The distinction of macrospores and microspores found only in the Rhizocarpeæ and Ligulatæ, and which, as already stated, initiated the transition from the Cryptogams to the Phænogams, took place in the same individual, both kinds of spores often occurring in the same sporangium, as in Salvinia. This, when the two kinds of spores at length came to represent the two sexual organs of the Cycad or the Conifer, necessarily reunited the sexes once more in the same plant, and the process of separation, so well completed in the higher Cryptogams, was required to be begun anew on the higher Phænogamic plane of development.

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From this point, however, the history of this process is of the highest interest. In the Cycadaceæ complete diœcism was reached before any of the few now existing forms were developed, and all present living species are male and female. In the Coniferæ, different families have attained to different degrees of diclinism. The Taxineæ, which many facts show to have been among the earliest forms developed, are diœcious, while the great pine and fir tribes, as well as most cedars, are still monœcious. Both these great orders have come down to us from the Carboniferous epoch, and indicate, along with the remnant which we possess of the then luxuriant cryptogamic flora, the kind of vegetation which prevailed in those remote ages. The flowers even of the highest forms were uniformly inconspicuous and odorless. The only possible substitute for sexual separation was the distribution of pollen by the winds. Forms so high in development, it would seem, could not continue to exist through self-fertilization alone, and hence, under the operation of natural selection, more or less complete sexual separation early took place.

The transition from the Gymnosperm to the Angiosperm is veiled in great obscurity. Certain considerations point to the gradual transformation of the Cycadaceæ into the Monocotylæ through the Palmaceæ or some allied family, on the one hand, and to that of the Coniferæ into the Dicotylæ through the Gnetaceæ and Casuarineæ, on the other. However this may be, the earliest known fossil species of Angiosperms, dating back to the early Trias, consist of poplars, beech, oak, chestnut, sycamore, and other unisexual and diœcious trees, all of which want the showy flowers characteristic of the present flora of the globe.

In view of the fact that this early flora was to so great an extent diclinous, it becomes an important question why so large a proportion of the present flora is hermaphrodite. We find that many of the plants of the most recent geological development possess the means of self-fertilization within the same flower and no obvious means of crossing

individuals. Upon closer observation, however, we perceive that many of these apparently perfect flowers possess arrangements of a more or less anomalous kind, which, inexplicable on any other theory, are all explainable as contrivances for the prevention of self-fertilization. The com|pleteness with which this object is accomplished
93 is of all degrees, from Epilobium with its style merely turned to one side, to Iris with its short extrorse anthers hidden away under the broad styles stigmatic on the inaccessible side; from mere heterostyly to complete dichogamy.

I need not review the conclusive reasoning by which all these morphological modifications are accounted for as the results of the long continued agency of insects. It is important only to point out that this influence has been powerful enough to reverse the entire course of sexual differentiation, which, as we have seen, has been in all lower forms constantly in the direction of a more and more complete separation of the sexes. It may be said that this proves too much, since progress in that advantageous direction once gained would not be likely to be lost. The sufficient reply to this is that, independently of the natural tendency to revert to the normal or monosexual state, when the separative influences are withdrawn, the reserve power of possible self-fertilization when for any cause cross-fertilization fails, as it clearly often may, is a positive advantage, and one which, under the proper circumstances, natural selection will insure.

The most significant fact which palæontology reveals is that of the simultaneous appearance of an insect fauna and a hermaphrodite flora. When the insects came upon the scene they found only a diclinous flora with usually apetalous flowers destitute of both fragrance and color. The succeeding strata immediately commence to exhibit plants of the rose, mallow, magnolia, pulse, and crowfoot families with showy petals, often fragrant, and provided with special nectaries for the secretion of honey. Most of

these had already made their appearance in the chalk formation, while during the Tertiary the still more perfectly organized Gamopetalæ were developed. The agency of insects in the fertilization of plants and even in the transformation of flowers to adapt them to their uses is no longer questioned by any at all familiar with the facts, but wide differences of opinion exist with regard to the degree of this influence, and also to the meaning of particular facts. Much of this confusion is due to the prevalence of the notion to which attention was called at the outset, that all adaptation must be regarded as completed at the present time. This assumption of a statical condition in nature now, while admitting the necessity of a dynamical condition in the past, is | wholly gratuitous and belongs, as al- 94
ready remarked, to the same class of ideas as that by which all changes were once explained as the results of great and sudden catastrophes. It is due to the kind of reasoning which denies change to everything which can not be seen to move—a kind of reasoning which leads the savage to deny that the great trees have ever been other than they are,[1] while admitting growth in the herb and the sapling. In point of fact we find nearly all possible degrees of adaptation to the agency of insects. The mere existence of colored flowers must be regarded as an initial step in this direction, and the greater part of all flowering plants exhibit in a more or less marked manner this evidence of the influence which insects have exerted upon them. But it is evident that an ordinary hermaphrodite flower, however showy or fragrant, if devoid of special appliances for preventing self- and securing cross-fertilization, represents a very rudimentary and imperfect state of correlation to the insect world. This condition, which is now the predominant one, must therefore be regarded as constituting the first step of a long progressive series of morphological changes in the same direction, all tending to complete the degree of adaptation

[1] See an address by Maj. J. W. Powell, delivered before the American Geographical Society, at Chickering Hall, New York, Dec. 29, 1876.

to insect life. The various specializations which a few species have already undergone mark so many additional steps taken by such species toward the same end and afford a faint idea of what the whole flora of the globe might become in the remote future, if wholly uninfluenced by man.

In the great majority of plants, self-fertilization is doubtless still the rule, and cross-fertilization the exception, but this occasional crossing, even though very rare, suffices to maintain the vigor of the stock. Such plants will appear to thrive as well when self-fertilized as when cross-fertilized, and this would probably be the case if the experiment were repeated a great number of times, for it is not once or a score of times, or a hundred times even, that count in these processes of nature, but vast periods and innumerable repetitions, each with its minute differential to add to or subtract from the general sum. When these facts are properly understood, therefore, the partial or total failure of all human experiments on cross-fertilization becomes
95 nothing more than naturalists ought to expect. The really surprising fact in such | experiments is that some of them actually do show a clear difference in favor of cross-fertilization. It may be compared to the attempt of astronomers to obtain the parallax of a fixed star. The result is in the highest degree satisfactory if it is certain that any positive angle is measured. And, as in the astronomical parallax, the greatest exactness is required to measure the vastness of space and its contents, so in the biological parallax equally great precision is needed to measure the vastness of time and its effects.

Independently of insect agency, however, the vegetable kingdom furnishes many facts which prove the unstable state in which the sexual relations are still found to exist.

In many cases it is difficult to determine whether the movement is at the present time towards a greater or less degree of separation. In a former paper read before this

Association[1] I endeavored to bring forward the evidence to prove that certain species of Lauraceæ, and notably the genera Sassafras and Lindera, had already passed through three different stages, of which traces are still left in the form of "rudiments" or obsolete organs. In this case the movement has obviously been towards more complete sexual separation. In the majority of other common cases, such as Smilax, Ilex, Rumex, Rhus, Chamælirium, etc., where the rudiments of both stamens and pistils remain, though one or the other set is functionless and the plants are really dicœcious, the direction of development seems also to be towards sexual distinctness, and it may well be doubted whether the flowers of the oak, the alder, or the willow were ever hermaphrodite. Still, progress toward hermaphroditism may also be going on in some species where insect fertilization is found a sufficient substitute for the distinction of sex.

Upon the whole, however, it must be concluded that the special effect of the appearance of insects in the Mesozoic or Secondary age of geology was to render the evolution of new hermaphrodite forms possible, which vastly enriched the world's flora, since prior to that time only diclinous species could survive, and that this great army of plants, having been thus brought into existence in this imperfect condition, have since been gradually throwing off their encumbrance, and at different rates moving forward toward sexual independence.

[1] Published in the *Scientific American Supplement* of Sept. 20, 1879 p. 3089 [see *supra*, No. 100].

April (?), 1881 —Ætat. 39.

111. Pre-Social Man

History.—This is an abstract made by myself, considerably fuller than that made by Mr. Peters (see *supra*. No. **104**), of the paper read by me on April 20, 1880, before the Anthropological Society of Washington. The paper itself consisted of a portion of Chapter VI of *Dynamic Sociology*, which had not yet gone to press.

Abstract of Transactions of the Anthropological Society of Washington, Washington, 1881, pp. 68–71.

THE speaker said it might safely be given as the opinion of those naturalists who accept the animal origin of the human race that at some time and in some part of the world some one group, possibly a very limited one, of the ape family acquired certain of the characters which now distinguish the human from the simian anatomy. These characters he summed up as follows: Increased capacity of the cranium and increased size of the encephalon; greater complication in the mechanism of the larynx; the erect posture of the body; the plantigrade character of the feet; non-opposability of the great toe; diminished length of the arms in proportion to the trunk; greater or less absence of hair from most of the body and

limbs, and double curvature of the spine. Among these points of difference there was a certain interdependence, so that on the principle of adaptation they would all flow from some one or two of the chief ones, and he thought that the first of these characters to be acquired by the simian ancestors of our race must have been the increased size of brain, which might have resulted from the necessity certain apes were under, of depending on superior cunning for protection against animals of greater strength and ferocity than themselves; and this character once acquired, together with the modifications resulting from the substitution of terrestrial for arboreal habits, the rest would follow.

It was pointed out, too, that the immediate progenitor of man among the anthropoids might have been considerably nearer to the human form than any of the known anthropoids now are, as would be the case if there were a creature combining the full chest of the gibbon, the skull of the | chimpanzee, the short arms and man-like hands and feet of the gorilla, the size of brain of the orang-outang, and the features of *Semnopithicus*, *Cercopithicus*, or *Mormon*. That such a form once existed was as reasonable as that the orang-outang should exist. Increase of brain and accompanying increase of intelligence was due to two causes: 1, Efforts to evade enemies through the exercise of sagacity or cunning; 2, Efforts to obtain food by skill and strategy. The first of these was rendered necessary to a greater degree than in the case of other animals in consequence of a notable absence of the means of defence with which most animals are endowed. The second was also due in great part to the lack of offensive weapons and other specialized means of pursuing any one peculiar mode of life. To understand this better, however, another important fact must be considered. Nearly or quite all the animals of the family from which man has descended are strictly arboreal. They are usually light and supple creatures, adapted to life in trees, subsisting chiefly upon the nuts and fruits which they yield. But some of the anthropoids,

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the gorilla, for example, have attained so large a size and so great a weight that arboreal existence has become difficult and they have descended to the ground. The ancestor of man must have belonged to this class and early become at least a partially terrestrial animal. The effect of this was both to increase the number and character of his enemies and to diminish his supply of natural food. Both these circumstances combined in increasing the necessity for mental exertion which in turn was the immediate cause of his rapid brain development.

Two causes likewise, operated to produce the erect posture, namely: 1st, life on the ground, and 2nd, increased brain mass.

The conformation of the limbs of the ape family is such that life on the ground would naturally cause the fore limbs to be used more and more exclusively as hands, and the hind ones as the only means of locomotion. The enlarged brain accompanied by a still greater increase in the weight
70 of the | skull and other bones of the head would render the horizontal support of the head extremely difficult. The strict laws of mechanical equilibrium, therefore, operating cumulatively through the joint action of both these causes, would tend to elevate the forepart of the body until the spine should become vertical, the head be borne directly over this bony axis, the fore limbs completely exempted from duty as organs of locomotion, and the hind limbs devoted exclusively to that purpose.

Respecting the important attribute of speech it was maintained that it is the result of mental far more than physical development. The larynx of many animals, and particularly of the ape family, is known to be highly developed. The true reason why these animals do not possess articulate speech is because they do not possess sufficient intelligence to invent and employ arbitrary sound-symbols. That they cannot be expected to perform so high an intellectual feat was exemplified by the fact that microcephalous idiots having a brain capacity of less than sixty cubic inches are in-

capable of being taught to speak, although they possess a well developed larynx and behave in all respects like tamed animals, while the orang, whose brain is larger than that of any other ape, has an encephalon of only thirty-five cubic inches.

Thus, without any violent assumptions, it was shown that all the differences which separate the highest animals from the lowest human races can be accounted for by the natural laws of adaptation as now understood by naturalists.

The three questions of the unity, the local origin, and the antiquity, of the human race were then briefly considered. The first may now be regarded as temporarily, if not permanently, settled on the monophyletic basis. The second cannot be expected to be settled, or even placed, in a way of enlightened discussion, until the tropical regions of Asia and Africa shall have been thoroughly explored by paleontologists. As to the third enough is already known to enable us to class man along with many other of the higher mammals now found fossil, as a true product of geologic time. But the fact was strongly insisted upon that the 71
ordinary method of discussing all these questions was vicious, in failing to recognize the underlying question as to what constitutes a being—a man. As no true line of demarkation between apehood and manhood exists there is no fixed point, either genealogical, chorological, or chronological, from which to set out.

112. Savage and Civilized Orthoëpy

History.—Written December 20, 1880 to January 30, 1881. Read before the Anthropological Society of Washington, December 21, 1880.

Ibid., pp. 106–111.

THIS paper consists principally of remarks and strictures on the first chapter of the *Introduction to the Study of Indian Languages.*[1]

After quoting a preliminary paragraph from this work relating to the complexity and vagueness of the sounds in savage languages, Mr. Ward said that the two leading facts enunciated in it were: 1st, the multiplicity of sounds which the human races have embodied in speech; and 2d, the existence and prevalence of pseudo-sounds or the unstable forms of vocalic and articulate utterance which the author of the work quoted from designates as "synthetic or undifferentiated sounds." He claimed that philologists had failed sufficiently to recognize these two fundamental elements of linguistic study and proceeded to show from numerous examples drawn from the French, German, Italian, Spanish, and English languages that these character-

[1] *Introduction to the Study of Indian Languages*, by J. W. Powell, Washington, 1880; 4°.

istics, so far from being confined to savage or barbaric tongues are common to all languages even the most cultured. The most general fact adduced in support of this view was that all foreigners in learning another language pronounce it at first, and generally always, with an "accent" peculiar to their vernacular, and that this accent is often the most marked in sounds which all the books teach to be common to both languages; as in the attempt of Germans to pronounce the English word "will."

He accounted for the multiplicity of languages on the globe on strictly natural principles. The facts of phonology not less than those of morphology are the result of origi|nally fortuitous circumstances followed by strictly 107
mechanical adaptation to the infinitely varying conditions of existence. The truth should be clearly recognized that there is no fixed limit to the number and variety of sounds which speech may embrace except that which the capacity of the organs of speech for producing such sounds presents. If all the adjustments of which these organs are capable could be definitely known and accurately described in terms of the mechanical changes necessary to produce them, and each such *species* of sound, as we may say, were then conveniently named according to the methods of science, then the various syllables of a new language might be referred to established orders and classes, genera and species, and the science of phonology historically established. It might then be seen how utterly fortuitous the character of every language has been within the limits of its possibilities, and the immense diversity of languages, not in their word-units and sentence-units alone, but in their sound-units as well, would be no more inexplicable than are the variations which we see in animal and plant forms. The primary principle in acquiring a foreign pronunciation is to learn and to adopt the accurate position of the organs of the mouth; in fact, could this in all cases be done, failure to pronounce correctly would be a physical impossibility, since the sound is in each case the mechanical result of the relations of the speak-

ing organism and can no more differ from the character fixed by these relations than the pitch or *timbre* of a musical instrument can be other than that which its strings, keys, materials, &c., require it to be.

Mr. Ward then took up the letters and commented upon a considerable number of them with a view to pointing out undifferentiated sounds in modern languages, and also in order to emphasize certain errors into which different lexicographers have fallen and certain failures on their part to recognize distinctions almost universally made by English-speaking people. This was particularly striking in certain letters mentioned.

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| *Vowels: a.* What is called the short *a* in the French is a typical synthetic sound varying in the mouths of different speakers, even the best instructed, from that which it has in the English word *add* to the Italian sound as heard in *father*, which is scarcely more than a lengthening of the sound it acquires in the word *what* (equal to *o* in *not*), and fairly reaches this latter sound when heard in *pas*. In English, too, the *a* is sometimes of a very uncertain character, especially in such words as *last, glass, path*, &c.; also in such words as *bad, glad, mad, chaff, lag, salve, damp, rank, grant, gap, care, gas*. On these points lexicographers differ widely, and, as the speaker believed, much more widely than the public. The difficulty in most cases was held to be due chiefly to the imperfect discrimination by lexicographers of sounds which nearly all clearly distinguish in pronouncing, but which even those who do so can rarely recognize as unlike when the differences are pointed out by another. The only three authors who seem to have clearly perceived the true sound of *a* in the examples given are Fulton & Knight and Smart. All others, including Webster, Worcester, Walker, Johnston, Reid, Nares, Jameson,

Sheridan, Perry, Knowles, Jones, and Craig, whose views had been carefully examined by the speaker, had denoted the sound of this letter in these circumstances by symbols which would, if followed, entirely alter the pronunciation of the English language.

i. Relative to the sound of the English *i*, while admitting of course that the long sound as heard in *mind* is a true diphthong, equivalent to the Italian sound of *a* followed quickly by the English long *e*, it was maintained that the English short *i*, as in *bit*, &c., is not a mere shortening of the continental *i*, but is a distinct sound which can be indefinitely prolonged without change or tendency to assimilate that sound.| To pass from the one sound to the other was shown 109 to require a slight readjustment of the organs of the mouth.

o. There is one sound of the English *o* which is clearly synthetic, viz., that heard in the word *whole;* but this is the only word to which it applies, and uninstructed people vary it through the entire range of sounds from that of the *u* in *hull* to that of the *o* in *hole*. In French, however, this is the prevailing sound of the *o* and constitutes their short or unaccented *o*. It is there highly synthetic, being pronounced quite differently in different sections of France, and in the same section by different persons, and even in different words by the same person, cultivated as well as uncultivated. Numerous examples were given by the speaker.

The disagreements and misconceptions among lexicographers relative to this letter were shown to be similar to those in the case of the *a*, all of whom, for example, with the exception of Smart, give it the same sound in the words *dog*, *log*, *moss*, *cloth*, &c., as in the words *not*, *pod*, *bog*, &c. The speaker main-

tained that the former sound is identical with that of the *au* in *fraud*, or the *aw* in *law*.

u. Great misapprehension exists with regard to the long sound of the *u*, whether to give it in any case the Continental sound represented by *oo* in English, or to make it a diphthong as in *blue* (=*blew*) consisting of the short sound of *i* prefixed to that sound. The word *rule* which Maj. Powell selects as the type of the former pronunciation is much more frequently given the latter, though this seems not to be sanctioned. The short sound of the *u* as in *pull* was held to be, like the short sound of *i*, a distinct sound capable of indefinite prolongation.

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| *Diphthongs:* The speaker maintained that there were gradations among the diphthongs according to the sounds given to the components which would considerably increase the number given by Major Powell. For example, besides the *ai* (*mine*) there may be *âi*, and besides *au* there may be both *âu* and *êu*, which last is more nearly the common pronunciation of the *ow* in *down*, the example given by him, and which is quite distinct from the German *au* as in *Haus*. Only broad-spoken people give this sound in English. There are also gradations between the *ai* and the *âi* as exemplified by the German *eu*, *heute*, and *äu*, *Häuser*. On the Continent the chief distinction is in the degree to which the two sounds are kept separate. In Italian and Spanish the combination in *au* is not regarded as a diphthong, the two letters constituting as many syllables.

Consonants: Mr. Ward next proceeded to remark upon certain of the consonants. The German *b* and *p*, *k* and *g*, as also to some extent *s*, *t*, and *d*, he regarded as synthetic. The Germans simply take no account, in

pronouncing these letters, of the distinction between *surd* and *sonant*, they do not know in speaking whether they vocalize them or not. This exemplifies a principle which students of language should understand, viz., that in some languages *there are processes ignored in utterance*. Another example of this is found in the cockney pronunciation of *h*, where it does not belong and in omitting it where it should be heard. It is simply ignored and whether a word receives an aspiration or not depends upon rhetorical rather than orthographical considerations.

There is no line of demarkation between the aspirate and the guttural. Several steps of this interval are filled by the Spanish *j*, *g*, and *x*, and by the two sounds of the German *ch*.

| It was maintained that the trilled *r* should not be confounded with the English *r*. The latter is *sui generis*. In the former, besides the distinctive vibratory motion of the tongue, it is placed much farther forward, in a position which is about the same as that required for the pronunciation of *l*, and to which sound, therefore, this is really more nearly allied than to that of the English *r*. 111

The sibilate sound *s* varies greatly in different languages, the tongue assuming a position farther and farther forward in pronouncing it,until it finally passes, in the Spanish *c* and *z*, into the *th* of the English.

The German *w* and Spanish *v* are not, like the English *v*, dento-labials, but pure labials, and much nearer allied to *b* than to *v*. In the former the lips are not allowed to come into contact, and air is passed between them, giving a sound resembling that of our *v*, but organically wholly distinct from it. In the latter the *v* and the *b* are not only to a large extent confounded in sound, but also in orthography, as is evidenced by the large number of words which are indifferently written with the one or the other letter—e. g., *bacia* or *vacia*, *baho* or *vaho*, *bulto* or *vulto*, &c.

113. Politico-Social Functions

History.—Written February 22 to March 15, 1881. Read before the Anthropological Society of Washington March 15, 1881. An abstract of this paper appeared in the Transactions of that Society (see *infra*, No. **127**). On May 18, 1881, I received the following letter:

NEW YORK, May 16, 1881.

LESTER F. WARD, Esq.

Dear Sir:

I have been much interested in reading your paper "Politico-Social Functions." I think I may get our Board of Trade to send out a number of copies provided they do not cost too much. Will you please ascertain and advise me what they will cost in quantities of 500 or 1000 copies?

Yours truly,

F. B. THURBER.

I wrote to the publishers and also to Mr. Thurber, sending the letter to the former. They replied that they had made Mr. Thurber an offer, and returned his letter. I never heard anything more from it, having neglected to inquire.

The Penn Monthly, Philadelphia, Vol. XII, No. 137, May, 1881, pp. 321–336.

IT is a sign of an approaching crisis in social opinion, when prevailing theories become widely at variance with prevailing practices. While a certain amount of general depravity may be conceded, even to a progressive and apparently prosperous people, it is quite too much to insist that, because they are almost universally running counter to the received philosophy, they must necessarily be pursuing a downward course. They may simply be following social instincts; and when social instincts are found to be powerfully opposed to social tenets, it is time, while deploring the former, to pause, also, and examine the latter.

In one view, all truth is relative. Doctrines that were true for one age cease to be true for a later one; principles which really worked the salvation of the last century cannot be utilized in the present one. The conservative tendencies of society, which perpetuate customs and ceremonies after their usefulness has ceased, preserve also the great social theories by which past ages have been redeemed, and they hand them down to later times, with which they no longer stand in legitimate relationship. Feeling is more powerful than intellect. Society is always moved by the great tide of sentiment long before the voice of reason declares the nature of this motive power. When the tide once fairly sets | in in one direction, the philosopher knows 322
that there must be a force behind it; but ere he can investigate that force by the slow and cautious methods of science, and announce its true character, long steps will have been taken in the direction of the inevitable. This is a critical period. The interval between action and reason,—between new practice and new theory—is one full of dangers to society. For all the forms of feeling, as well as the particular form called love, are equally blind; and blind sentiment sweeping through new tracks, and encountering old theories and old practices, must inevitably produce innumerable conflicts and perpetually jeopardize the great interests which are at stake.

The second half of the nineteenth century is precisely such a period as that described. Theory and practice are at war. The only social philosophy that exists is one that condemns the bulk of the social action taken. The libraries of the world are filled with arguments against the very course which events are blindly taking. The whole weight of the greatest social writers of the past is massed against the social movement of the age. The works of Adam Smith and Ricardo, of Pitt, Cobden and the two Mills, of Jean Baptiste Say and Michel Chevalier, and of the train of political economists who have followed these leaders, while they abound in discords and contain many conflicting views, are, in the main, hostile to all those schemes of regulation which characterize the action of modern States. The political science of these masters is all there is to be taught in the colleges and universities, and it continues to be so taught. The representatives of science have joined their forces with the ones already named, and, with the added power which science has justly come to wield, stand boldly in the track of current events. There is also an able corps of living writers who are earnestly protesting against the tendencies of the times. The commercial and financial journals are filled with hostile flings at "Government meddling," and "bureaucracy"; the organs of transportation, telegraph, and insurance companies are daily holding up the dangers of "State regulation." The Cobden Club and other "Free Trade" societies are scattering tracts with a liberal hand, in the hope of stemming the tide. Victor Boehmert warns, Augustus Mongredien shouts, and Herbert Spencer thunders. What is the result? Germany answers by purchasing private railroads and enacting a
323 high protective tariff. France | answers by decreeing the construction of eleven thousand miles of Government railroad, and offering a bounty to French ship-owners. England answers by a compulsory education act, by Government purchase of the telegraph, and by a judicial decision laying claim to the telephone. America answers by an

inter-State railroad bill, a national education bill, and a sweeping *plebiscite* in favor of protection to home manufactures. The whole world has caught the contagion, and all nations are adopting measures of positive legislation. A large amount of crude law-making is being dictated by this blind impulse. Vast internal improvements are undertaken by Government, and millions are appropriated for commercial and industrial schemes. The wildest financial measures are seriously advocated, and both at home and abroad the public credit of the world was at one time seriously imperilled by Socialistic theories of national financiering. Cernuschi said "Nomisma"; and a large but irresponsible party sprang up in every civilized country and demanded that the State should create and distribute an abundance of the circulating medium!

What conclusion is the thoughtful student of social events to deduce from all this? The prevailing school of political economists think the world is temporarily mad, but hope that it will soon return to itself. They declare the entire movement baseless, and believe that all efforts should be directed towards diffusing and reinforcing existing theories, and they insist that there are no grounds on which the events described can be logically defended. In this they are undoubtedly sincere. Reform with them means simply a halt and reversal of prevailing tendencies.

But there is another possible policy, practicable also for those who really desire reform. It is an adage that reforms never go backward. It is always well to inquire whether, underlying a great movement, however perverse it may appear, there may not be a basis of truth concealed by the errors that lie on the surface. In such cases true reform may not consist in open opposition. This may often be fruitful of harm, and usually is fruitless of good.

In the present state of society, the movement above sketched is irresistible. This is sufficiently proved by the powerlessness of the influences allied against it to check it. It behooves all true reformers, therefore, to cease factious

opposition, and settle down to the soberer task of studying the causes of the phenomena observed. Society | needs
324 less to be told that it is doing wrong than to be shown what it is really doing. If there must be a movement in a given direction, let its true nature be made known. The jars and evils are due, not to the advance itself, but to the clashing of interests which ignorance of their existence and of the whole field swept over renders inevitable. The true need is for enlightenment respecting the causes and consequences of action, by the aid of which alone these conflicts can be avoided and the movement intelligently guided.

In what consists this schism between theory and practice? It is after all a schism between two theories; for all action is based on theory, if it is nothing more than a blind intuition of selfish and momentary benefit. In the present case it is much more. Fundamentally formulated, it is the theory of natural, against that of artificial regulation. The belief in some form of regulation is one deeply implanted in the human mind. A supposed divine regulation of human affairs was the first form in which this belief manifested itself. Then, when government was exercised chiefly by one man or a few men, the belief in the power of these rulers to regulate society was long supreme. It is only since the civilizing agencies of printing and of science have been at work, that this illusion has been dispelled. But in its place the only alternative clearly perceived has been accepted, viz., the idea that nature and the laws of nature are alone competent to regulate the affairs of men. This theory was plausible. It was supported by the spontaneous growth of numerous great industries; it was strengthened by the failures of human regulation in the past, and by the continuance of such failures in the present. It was thought to be in full accord with all the teachings of science which had so greatly contributed to relieve the world of the yoke of despotic regulation. Science taught the uniformity of all of nature's processes. It taught that the universe was controlled by fixed and unchangeable laws which could not

be violated with impunity. Progress in nature was due to the secular operation of these laws, which could neither be slackened nor accelerated. Political science followed strictly in the path of physical science. It declared that commerce and industry were controlled by uniform laws of nature which man must interfere with at his peril. The laws of trade must be allowed to take their course. The improvements necessary to further civili | zation, to be real or substantial, must be spontaneous. Great sys- 325
tems of commercial intercourse, of productive industry, of transportation, intercommunication, finance, and education, would naturally work themselves out, provided the potential qualities necessary for them existed in society. Every attempt on the part of Government to interfere with these great processes of nature only recoiled upon the agent and imperilled the safety of the State. Government must protect—it must not control; it may forbid —it may not command.

Such was the theory which very naturally grew up at a time when it was greatly needed, and emancipated society to such an extent from monarchical and oligarchical rule, that nearly every one of the pretended monarchies of Europe is to-day a virtual democracy. And this is none other than the present prevailing theory of political economists; the one which is embodied in our masterpieces of literature and philosophy, is taught in our colleges, preached in our pulpits, echoed from our rostrums, served up daily by the press, and advocated by many of the most learned men of the time. And now, in these later days of republican institutions, which, as already remarked, it has done much to secure, it finds itself again confronted by an enemy which it cannot distinguish from the old one that it formerly encountered and drove back.

Just here is the great mistake. In so far as artificial regulation in itself is concerned, the modern theory is indeed identical with the original one; but here the parallelism ceases. Government under a real autocrat is the

interference by one man with the affairs of millions. Government by popularly chosen representatives is the management by society of its own affairs. This may be true only in theory, but it approaches realization in proportion as representative government approaches perfection.

Now, precisely the conception which vaguely, but not the less obstinately, inspires all the apparently rash tendencies of our times, is that society ought to take its affairs into its own hands, check the abuses of unrestrained competition and combination, and consciously work out certain of the problems of civilization. Against the negative theory that nature must be left to bring about social progress in its own time and way, it holds that nature may be assisted by organized social action, very much as the *vis medicatrix naturæ* may be assisted by intelligently directed ap-
326 plications of | the healing art. Not, however, that individuals, legislators, or Governments consciously reason out such a scheme. On the contrary, they scarcely know that they are carrying it out, and would in most cases deny it, if openly charged with it. In fact, nearly all classes—even those who are wielding all their influence against it—profess to admit the truth of the prevailing theory. They do not realize, and generally do not know, that they are antagonizing it. They wince under the charges of the theoretical school, and confess or make no response; yet they are not deterred from their work. There is no fixed set of doctrines laid down to govern this movement. Acts advancing it are not defended by argument. It is an impulse without a philosophy; an instinct rather than a conviction. Yet it is deep-seated and ineradicable, and its smouldering fires often burst into view in the form of prejudices and passions. There is a sentiment that something is wrong, and a feeling that something should be done. The opposite school does not share these feelings. It condemns every attempt to *do* anything. "*Laissez faire, laissez passer,*" said De Gournay; and with these words was christened the *laissez faire* school of political

economists. These writers deride the mistakes of Governments in the past in trying to perform positive functions, and show that such attempts have usually resulted in failures, and often in mischief. All their utterances and teachings imply that it is folly to undertake the control of social events, and wisdom to leave them wholly to the untrammelled influence of what they call natural laws. As above remarked, almost everybody, if separately questioned, would admit this position, so completely has it become part of the education and thought of the present age; and yet, often without perceiving the inconsistency, many entertain a vague but powerful sentiment in favor of mending existing evils, of regulating social events, and of doing something very decisive in many ways.

It is this insidious manner in which these two incompatible theories coexist, often in the same individual, and permeate society, that complicates the problem and creates the urgent need of a clear presentation of their respective claims and a thorough acquaintance with their nature and aims. If man was really, as is often claimed, a rational being, in the sense of always acting upon reasoned-out conclusions, there would be no difficulty. It would then resolve itself into a simple trial of strength between two well | defined parties. But as it is, every house is, as it were, divided against itself. A political speaker may 327
harangue an American audience on the dangers to be apprehended from the centralization of power, from Government interference in private enterprise, from an army of paid office-holders striving to do the business of the country, from attempts of the State to manage lines of transportation and intercommunication, from legislation granting subsidies to rich corporations or taking from the people the right to issue bills of exchange or solicit deposits; and all these sentiments will be applauded. Another speaker may address the same audience the next day, warning them of the dangers from grasping corporations, from industrial, commercial, and financial monopolies,

from fraudulent bankruptcies and dishonest failures; and he, too, will receive equally unqualified approbation. The workingman may be excited to the pitch of belligerency by telling him that the clothing he wears, the cutlery and tools he uses, and much of the food he eats, are far dearer than they would be but for a protective tariff which enables certain monopolists to put up the prices of the commodities they manufacture; but the same individual could have been wrought up to the same pitch by informing him that a given increase in the duty on certain articles of foreign importation would enhance his wages a given per cent. and that certain persons are trying to reduce these duties still lower, so as to compel him to compete with the pauper labor of Europe. Yet, while in the first of each of these hypothetical cases the appeal is such as would come from the school of *laissez faire* economists, in the second it is, in both cases, that which would come from the school of State regulation.

These examples, however, will help us to obtain a glimpse of the foundation upon which this latter school stands. Science and natural law to the contrary notwithstanding, it remains, and always has remained, a patent fact, that social events, left to themselves, are always attended with glaring evils. There is no necessary harmony between natural law and human advantage. The laws of trade inevitably result in enormous inequalities in the distribution of wealth. It may, with much truth, be argued that considerable inequality is the better social condition; but the degree and kind of inequality which is actually reached cannot be defended on this ground. The fact is too apparent that all this inequality is not due to the superior intelligence or industry
328 of those who possess most, | which, thus limited, many might be disposed to declare just. It is obvious that mere accident of birth or position is sufficient to account for the great bulk of this inequality; that real intelligence, beyond the coarse cunning inspired by avarice, has little or nothing to do with it; that the primary producers—that is,

the discoverers and inventors of the laws and appliances by which the production of wealth is accelerated—have generally enjoyed few or none of the advantages of their intellectual efforts, but that these are reaped by men of very moderate abilities beyond a certain business shrewdness and tact; that the immediate creators of wealth—the bone and sinew of labor—are, in nearly all cases, poor, while princely fortunes fall, for the most part, to the class who, far removed from all the objects of production or exchange, busy themselves solely with the medium of exchange or with mere transfers of entries representing the value of commodities produced and exchanged.

Again, natural laws do not prevent monopolies. The theory is that competition will keep down rates and prices; but the fact is that there is so much coöperation attending competition, when neither is under any control, that the former influence is exceedingly limited in its effects. These are chiefly seen in the swallowing up of small industries by larger ones. Competition results in great irregularity and an uncertain state of affairs. Rates and prices frequently fall below the cost of conducting business. This, while it might be continued under national control, where it has no other effect than to alter the distribution of the burden of supporting it, must be of short duration with private individuals or corporations, and soon be followed by failure, involving heavy losses not only to the parties immediately interested, but to the general stock of the world's capital. In short, the uncontrolled operation of natural laws in social affairs involves immense waste of created wealth. The ruinous lengths to which unlimited competition is capable of running, is a subject of common remark. Those who imagine that anything is thereby gained to the public, are greatly mistaken. Men are limited in their judgment, and fail to foresee remote consequences. Great experience has to be acquired, usually by repeated destructive failures, before the ability can be gained to conduct a business. Yet no one is so wild as to advocate the

regulation of private affairs of this class. Altruistic sentiments form no part of the great movement under consideration. Both parties are | quite willing to let every one
329 suffer for his own follies, however innocently he may have come by them. It is only where these numerous failures in private or corporate management strongly affect great public interests and jeopardize the public safety or comfort, that remonstrances are raised. When banks fail and thousands of innocent depositors or holders of their notes lose the proceeds of years of frugality and toil, when competing lines of transportation and travel so reduce their rates as to run at a loss, and, as must happen, lose also their proper interest in the public, thereby endangering both property and life, it is in such cases that the demand is made for State regulation.

It is not, however, always true that competition, even while it lasts, has the effect of lowering rates and prices. Bismarck startled the *Reichstag* by the bold announcement that the reverse was the case, and he substantiated it by statistics of British railroads before and since their amalgamation. He might have supported it even better by facts nearer home. It arises from the law that competition makes the supply exceed the demand. True as this law is of productive industries, it is doubly true of distributive ones. It multiplies the number of shops far beyond the necessity, each of which must profit by exchange, and in order to do this all must sell dearer than would otherwise be necessary. The immense number of hotels, restaurants, and eating-houses in every city, nearly doubles the necessary cost of living. The reduction brought about by competition is only relative and apparent. The fluctuations are between prices artificially strained to meet a superabundant supply. France has recognized this truth, and, in the matter of railroads, has prohibited their construction for the mere purposes of competition, as is the constant tendency of the unregulated industry.

But while this waste and disorder through unrestrained competition constitute in reality the more serious question for the true economist, monopoly through unrestrained combination is the more vital one for the unphilosophical public. This last, however, is the natural successor of the first. Extreme competition and extreme coöperation are but the crest and trough of the great ocean swell of unregulated social events.

The world to-day is alarmed—whether justly or not, it matters not—at the prospect of unlimited combination among the vast cor | porations already in existence. 330
These gigantic enterprises are regarded as threatening to crush out all competition and place every form of product at their mercy. That they have the power to do this, no one can doubt, and their only fear is social revolution. Under the laws they are omnipotent; they dread only the "higher law," and anarchy, which sometimes becomes more tolerable than government by law. Moreover, these immense monopolies are the legitimate product of natural law. They represent the integrated organisms of social evolution.

The world is also alarmed at the encroachments of capital. The national debts of the world have increased during the last century, under the prevailing doctrines of political economy, about one thousand per cent. They now amount to $28,337,200,000, or thirteen per cent. of the total wealth of the globe. The debts of dependent States and of cities and towns are on a similar scale. The local debts of the United States are estimated at $1,100,000,000. To these must be added the debts of corporations and private individuals, wholly undeterminable, but almost as inconceivable in amount. "Half the labor of the world," says a leading financial journal, "is required to pay the interest on its debt." Yet capitalists are still reaching out and daily laying still larger portions of the earth's possessions under tribute to themselves. Such is the nature of things, that each increment to their wealth gives them a disproportion-

ately enlarged power to add new increments; and the finite mind is incapable of discerning any limit to this process. If we again turn to Nature, we find, as before, that this is according to her method. She never, so far as human observation goes, has been known to yield up the fruits of her progress, and natural progress always consists in just this process. There is only this difference—man can repudiate, while world-systems are "bound fast in fate." And here, also, as before, it is not nature and law that are apprehended, but repudiation and the overruling of the lower physical forces by the higher psychic force. This is the only check to the unlimited absorption of the value of the world's products by the few who chance to stand in the centre of these attracting circles.

Lastly, it is not true that all attempts at Government regulation and State management have failed or wrought only mischief. State postal management is admitted by nearly everybody to have | proved a success. City
331 corporations now universally undertake the work of extinguishing fires, as being too closely connected with the interests of all to be entrusted to private enterprise. There are still a few who condemn the public school system, such as it exists under State and municipal regulation, but it is generally conceded that the people are considerably better educated than they would have been had education been left entirely to private efforts. These exceptions, if such they may be called, together with some others, apply to the United States with a very weak Government, which is jealously watched by a suspicious democracy, ready to hurl its *personnel* from power for the slightest departure from their prescribed duties. But when we look to the Old World, we see that these so-called encroachments upon individual rights have progressed much further.

Our mother-country—Great Britain—is most like us in this respect, but it has carried the work of regulation and State management so far as to embrace the telegraph-system, along with the post-office; and recent reports show

that, for the eleven years during which this has been the case, the results have been in the highest degree satisfactory. In this brief period the telegraph-system and operations of the United Kingdom have about quadrupled in all directions; the lines have been self-sustaining, and uniform rates, much lower than the former ones, adapted, like those of the post-office, to the common people, have been established.

Great Britain has not purchased any railroads, although it has long held this sword of Damocles over them in the form of a Parliamentary enactment (7 and 8 Vict. c. 85) reserving the right to do so. It has, however, enacted an entire code of regulative railway laws, and for the past eight years there has existed a special judicial commission or railway court, which is an integral part of the Government. By these means rates are established and innumerable details are arranged by the State to insure just dealings between the railway companies and the public. These are fixed measures which the British public could not be induced to rescind, and which may therefore be regarded as successful.

If we go to the Continent, we find a still greater advance in this direction. The greater part of the railroads of Germany and Belgium are owned and worked by the State; in the former case | mostly by the separate States of
the Empire. In France, while the most of them are 332
still nominally in the hands of private companies, such is the degree of national supervision that all rates and even time-tables are fixed by the Government, and no new private lines are allowed to be constructed. Moreover, the charters of many of these lines are soon to expire, and by the terms of the concessions the State has the right of purchase. This it has announced its intention to do, so that before many years the entire network will be in the hands of the Government. Add to this that France has already planned and commenced the construction of 17,700 kilometres of new Government railroad, and has also pur-

chased several of the former lines which it is itself successfully managing.

Prussian statistics show that freight is carried on an average fifteen per cent. cheaper on State than on private lines, and that passengers are carried ten per cent. cheaper, while no road is run at a loss and all are a source of revenue to the State. Italy, in the matter of railroads, is following the example of France in almost every particular, and other countries are moving in the same direction.

As regards the telegraph, many Continental countries have handed it over wholly or in part to the control of Government, and the tendency is steadily in this direction and nowhere in the opposite one.

Government savings-banks, in which the poor mechanic's earnings are rendered perfectly secure, are now almost universal in Europe, and these, as might be easily foreseen, have proved a complete success.

Everybody knows something of the system of public instruction in Germany. Nothing could induce the Fatherland to surrender it. Something closely approaching it exists in Austria and Hungary, as well as throughout Scandinavia, while France, Italy, and Belgium are rapidly extending their educational systems. Even England has taken a long step in this direction, in which it persists, against the attacks of many eminent writers. In 1870 it created School Boards, which it empowered to require parents to send their children to school; and, in 1876, it made it obligatory on all parents to provide elementary education for their children. The result has been that in that time the number of schools, of pupils, and of teachers, has increased over 100 per cent.

333 | Finally, the doctrine of protection to home industries must be admitted to be rapidly coming into favor across the water, whether in the form of increased duties on certain articles of importation, or of subventions to domestic shipping and other native enterprises. And here again, in England, the specious term "countervailing duties," is

not mild enough to conceal a growing sentiment in favor of regulating British trade.

These several acts of human government are not inoperative; they are not failures; they are not admitted by the people of these countries to have been productive of an excess of evil.

But we may go much farther. Of what does government consist? It consists, when rightly understood, simply of a collection of just such cases in which matters of general public interest have been taken out of the hands of individuals and assumed by the central authority. As soon as one such industry becomes permanently established as a proper object of national administration, it drops out of the list of those which it is deemed necessary to defend against Government encroachment. Each one of the body of regulative agencies which constitute the present accepted sphere of normal governmental functions has passed through this stage before settling down into its present place. We see this clearly in the history of finance and the bitter opposition to national banking. We may see it still more plainly where no one ever thinks of looking—in the progress of jurisprudence. It is, comparatively speaking, only recently that in Europe people were obliged to administer their own justice, both civil and criminal; and this is still the prevailing custom among many barbaric peoples and savage tribes.

Government has ever been constantly encroaching upon these supposed private rights, in the interest of the public good; and, though always opposed, it has always been slowly gaining ground. And, whether we like it or not, this process is destined to continue until, one after another, all the important public operations of society shall come more or less directly under the power of State regulation. Contrary to the general belief, this result is not often reached before the time is ripe for it. Such is the aversion to innovation, that the evils of private management usually become well-nigh intolerable before the State is able or

willing to step in and relieve them. While, therefore, progress in the direction of | enlarging the sphere of
334 Government operation should be very slow and cautious, such is the constitution of society and of the human mind, that there is less danger than is generally supposed that this will take place too rapidly.

The objectionableness of this movement is in great part attributable to the necessity of applying to it terms which, during the transition period above described, have come to receive a certain stigma or reproach. The administration of justice is now regarded as a highly proper function of Government, one which society is in duty bound to perform. The carrying of the mails has already become a recognized Government duty. Only those who desire to profit by issuing private bank notes now wish to return to that system of banking. The State management of railroads in Belgium has proved so satisfactory to the public that petitions are pouring in praying the Government to expropriate the remaining private lines, and there, at least, this, too, will probably soon pass to the side of legitimate national operations. As much may be said, in a large portion of Europe, of Government telegraphing, of national savings-banks, and of public education; and the world will probably wonder in the future that a patient public should so long have permitted the avarice of individuals, under the legitimate operation of natural laws, to play havoc with the public health in the adulteration of food, medicines, and dyes, etc., and in the improper construction of private and public buildings. The maxim, *caveat emptor*, of the common law, is simply a premium on dishonesty, and a proper understanding of its workings must reverse it and substitute *caveat vendor*, who is supposed to know the quality of his wares and deserves their confiscation for the offence of misrepresenting it.

The stigma which now attaches to the term "Government regulation," is, therefore, simply that which individuals, seeking to profit by the absence of it, have ingeniously

fastened upon it. It applies only so long as there is hope of defeating State interference in the excesses of private competition and combination. As soon as this hope is definitely surrendered these operations become legitimate Government functions, and Government is then abused, if at all, only for not performing them in a wholly infallible manner.

What term, then, shall be employed to express this conception free from reproach and with sufficient latitude to embrace both classes of cases, viz., those which are now recognized Government | functions and those which are still disputed and characterized as Government 335 encroachments upon the domain of private enterprise? It is clear that there is no such term now in common use. The conception, though a simple one, requires not only a circumlocution, but an elaborate explanation, to make it intelligible to the popular mind. For the popular idea of Government is extremely crude. It is looked upon objectively—as an outside power—hostile rather than friendly to the interests of society; and it must be confessed that this manner of looking at Government goes far towards making it what men are willing to regard it, and towards giving to the holders of political power the impression that they are above, and independent of, society. But every theory of Government must regard it simply as the agency by which society transacts those affairs which are recognized to be of a public character. All the difficulties of which we have spoken, therefore, have arisen from the effort to determine the boundary line between affairs of an essentially public and those of a private nature.

Regarded as the agency of society, it is clear that the acts of Government, theoretically at least, are simply the acts of society through its chosen agents; and Mr. Herbert Spencer has ably shown that even the most despotic forms of Government really reflect the average will and character of the units composing such societies. Opposition to

Government regulation is, therefore, in the nature of an attempt to frustrate the will of society as it is constituted to express it; but so long as such opposition is successful, this is itself the proof that the acts opposed do not properly represent the social will as thus constituted, since the only test of this will is the power to enforce it, no matter what the form of Government.

Thus viewed, the entire movement of which we have spoken becomes a social movement, and the conflict must be between individuals and society at large. The question in each case is, then, shall individuals continue to control this industry, or shall society henceforth control it? We have seen that the sphere of social control has been gradually expanding throughout the periods of civilization, sometimes, perhaps, too rapidly, but usually too slowly; and now we find that for more than a century the English school of negative economists has devoted itself to the task of checking this advance. This *laissez faire* school has entrenched itself behind the fortifications of science, and while
336 declaring with | truth that social phenomena are, like physical phenomena, uniform and governed by laws, they have accompanied this by the false declaration and *non sequitur* that neither physical nor social phenomena are capable of human control; the fact being that all the practical benefits of science are the result of man's control of natural forces and phenomena which would otherwise have run to waste or operated as enemies to human progress. The opposing positive school of economists simply demands an opportunity to utilize the social forces for human advantage in precisely the same manner as the physical forces have been utilized. It is only through the artificial control of natural phenomena that science is made to minister to human needs; and if social laws are really analogous to physical laws, there is no reason why social science may not receive practical applications such as have been given to physical science.

To distinguish this general movement in the direction of

regulating social phenomena from all other facts in human history, and at the same time to avoid all objectionable terms and express the conception in its widest sense, it may be appropriately denominated *Sociocracy*. It is too late now to object to this new term on the ground of its hybrid Græco-Latin etymology, since the Greek language is known to be deficient in a proper root for its first component, and several kindred terms are already in common use by the best authorities. It means something quite distinct from Democracy, which points, as this term does not, decisively towards a definite form of organization. The term Socialism, too, which might seem akin to it, aside from its unpopularity, has by far too great definiteness, and looks too much to fundamental change in the existing status of political institutions. All of these forms of social organization stand opposed to other existing forms, while Sociocracy stands opposed only to the absence of a regulative system, and is the symbol of positive social action as against the negativism of the dominant *laissez faire* school of politico-economic *doctrinaires*. It recognizes all forms of government as legitimate, and, ignoring form, goes to the substance, and denotes that, in whatever manner organized, it is the duty of society to act consciously and intelligently, as becomes an enlightened age, in the direction of guarding its own interests and working out its own destiny.

114. [Letter to John W. Mears Relative to the Centennial of Kant's Kritik der Reinen Vernunft]

History.—Written March 6, 1881, not, of course, intended for publication. In this number of the *Journal of Speculative Philosophy* the leading article is on "The Kant Centennial," which was Dr. Mears's address, delivered by him at Concord, Mass., August 4, 1881. It is followed by "Notes and Discussions," including "Correspondence" relative to that event. Under the latter head a large number of letters received by him are published, including my own. The date does not appear, but seems to have been March 7, 1881.

The Journal of Speculative Philosophy, New York, Vol. XV, No. 3, Whole No. 59, July, 1881, p. 297.

I INTENDED sooner to have expressed my approval of your proposed Centennial of Kant's Kritik, made in the *Penn Monthly* for December, 1880, which I read with pleasure and interest. In case a convention is held, I would be glad to receive notice of it at least, even though

I should not be able to attend. If I contributed anything, it would probably fall under your second rubric, and treat of the Antinomies in the light of modern science. I am acquainted only with the Kritik and the "Theorie des Himmels," which I have read in the original and annotated somewhat. Everywhere I felt that I was communing with a master mind, whatever might have been its *objective* deficiencies.

115. The Animal Population of the Globe

History.—Written November 1–2, 1880. This, it will be seen, is an abstract of the paper entitled, "The World's Supply of Live Stock" (see *supra*, No. **108**), with a few reflections added. The entire paper was read before the Philosophical Society of Washington on October 23, 1880, the tables placed on the board, and fully discussed.

Bulletin of the Philosophical Society of Washington, Washington, D. C., Vol. IV, 1881, pp. 27–29.

MR. LESTER F. WARD stated that he had recently had occasion to compile, chiefly from official sources, the statistics of live stock in the various countries of the globe from which any data could be obtained, and thought that some of the general results arrived at might possess sufficient scientific interest to warrant laying them before the Society.

The whole number of countries from which information of this character had been collated was twenty-seven, embracing all the countries of Europe except European Turkey, the several British Colonies in Australasia, the

Island of Ceylon, Cape Colony and Natal in South Africa, Mauritius, the Dominion of Canada, Newfoundland, Jamaica, the Argentine Republic, Uruguay, Chili, and the United States. The species of animals of which cognizance was alone taken were: horses, mules, asses, horned cattle, sheep, goats, hogs, buffaloes, and reindeer. The reports were very incomplete except with respect to the four leading species, viz., horses, cattle, sheep, and hogs.

The total number of each species actually reported upon was as follows:

Horses	47,181,384	
Mules	3,474,391	
Asses	2,217,166	
Mules and asses, not distinguished	11,849	
Horned cattle	157,598,521	28
Sheep	382,763,015	
Goats	15,704,911	
Hogs	81,691,331	
Buffaloes	89,281	
Reindeer	96,567	
	690,828,416	

The only species for which an estimate had been made of the total number in the world was the sheep. Mr. Robert P. Porter had made such an estimate, which, though varying from the official data in many of the above countries, afforded a basis for extending the figures already obtained to the remaining portions of the globe, and according to which the ovine population of the earth would reach 577,763,015. Using this result as a basis, a very rough estimate of the number of each of the remaining species in regions not already covered by actual enumerations would place the aggregate number of all the species named throughout the world at a little upward of one billion head and their distribution would then be about as follows:

Horses	70,770,597
Cattle	236,397,781
Sheep	577,763,015
Hogs	100,000,000
All other animals	32,391,247
	1,017,322,640

Reasons were, however, given for regarding this estimate considerably too low, both as to the number of sheep, upon which it is based, and also in the aggregate, and the speaker thought that the latter would probably reach nearly a billion and a half.

Comparisons were then made with the human population. According to a recent work by Baron Kolb the population of the 27 countries, from which reports were obtained, amounted, in 1878, to 366,100,000. This would give, upon an average, in all these countries, 130 horses, 430 cattle, 1,046 sheep, 224 hogs, and 29 of all the remaining animals taken together, to each 1,000 human beings, and for all these species combined, 1,887 animals to each 1,000 of population.

29 The latest issues of Behm & Wagner's *Bevölkerung der Erde*, (No. 6), gives the present population of the earth at 1,456,000,000. If the above estimates of the number of each of these classes of animals in the entire world could be relied upon, they would show, for each 1,000 of human population, 50 horses, 166 cattle, 407 sheep, 70 hogs, and 23 of the other species taken together, or 716 of all the kinds enumerated. But, as above stated, these figures are probably far too low, and, if the truth could be known, it would probably be found that the animal population within these limits would not fall far below the human population.

The paper was concluded with some general observations on the moral bearings of the question of animal domestication. It was held that these facts constituted a sufficient

justification of man's general treatment of the brute creation; that a larger amount of animal life exists under man's influence than could exist without it; that he creates more life than he destroys; that his methods of destruction are less painful than those of Nature; that it is to his interest to treat animals well, to supply them with abundant food, and relieve them from those constant fears, both of enemies and of want, which characterize their condition in a wild state; and that when life is taken, it is done quickly and as painlessly as possible; that the reverse of all this is the case in Nature, and hence a great amount of human sympathy is wasted on the creatures under man's control in consequence of ignorance of a few facts and principles.

116. Field and Closet Notes on the Flora of Washington and Vicinity

History.—Written May 27 to June 19, 1881. Read before the Philosophical Society of Washington January 22, 1881, from notes and manuscripts selected from the larger work: *Guide to the Flora of Washington and Vicinity*, soon after to be published (see No. **119**). I had considered that sufficient, but the Committee on Publications thought that the Society should have credit for it, and, through their Chairman, Capt. (later Major) Dutton,[1] they requested me on February 1st to furnish a full abstract of my remarks. The next day Professor Baird accepted my "Guide, etc." as a Bulletin of the United States National Museum. I told Capt. Dutton that it would be so published, but he would not excuse me on that account from furnishing a full abstract for the *Bulletin of the Philosophical Society*. I therefore proceeded to prepare it. I left for the field in the Far West in July and the proofs were not, indeed could not well have been, sent to me.

[1] His death occurred on Jan. 4, 1912.

The consequence was that a large number of typographical errors were made in the botanical names. I counted just 99 such. These are of course corrected here.

I should mention the fact that the appeal which is made in this paper on pages 72–73, for the reservation of the Rock Creek Region as a National Park, was ultimately responded to, and this region is now mostly included in the Rock Creek Park and the Zoölogical Park of Washington. To what extent my words really contributed to this result I would not attempt to say, but there are certain circumstances that lead me to believe that it had an influence. The most important of these was that very soon after this the eminent landscape gardener, Mr. F. L. Olmsted, became the Landscape Architect of the Capitol Grounds. The statement here made was repeated verbatim in my *Guide to the Flora of Washington and Vicinity* (pp. 19–20), and in Mr. Olmsted's Appendix to the Annual Report of the Architect of the United States Capitol for the fiscal year ending June 30, 1882, by the Architect Edward Clark, he (Mr. Olmsted) makes extensive use of my *Flora*, quotes from it, and mentions the regions described by me, especially the Rock Creek Region. That he was influenced by my statements is clear from the regret he expresses that these "sylvan treasures of the capital" . . . "cannot in some way be protected against the destructiveness which the hope of the smallest private pecuniary profit is liable at any moment to bring upon them." He sent me

this Appendix, and soon after I made his personal acquaintance. I am very sure that in our interviews I referred to this subject. I do not doubt that he did all in his power to induce Park Committees to consider the claims of this region, but I know nothing of the history of the ultimate selection of the Rock Creek Region as a National Park. It was not done till many years after these events.

I mention this in the sketch of this article instead of that of the *Flora* (No. **119**) on account of its earlier date, as showing how early I had been agitating the subject.

Bulletin of the Philosophical Society of Washington, Washington, D. C., Vol. IV, 1883 (this fascicle distributed Oct. 27, 1881), pp. 64–119.

[Mr. Ward's communication presented to the Society only a brief notice of the principal points of a monograph which he had prepared upon the flora of the District of Columbia. In view of the local character of his subject, and of the thorough and commendable manner in which it had been elaborated, the Committee on Communications recommended, and the General Committee authorized, the printing of a very full and copious abstract of the paper, which is given herewith.

This paper will be published entire, with an appendix, as Bulletin No. 22 of the U. S. National Museum.]

INTRODUCTORY REMARKS.

THIS paper has resulted from a suggestion made to the writer in the spring of 1880, by a member of the Committee on Publications of this Society, relative to the need that exists for some special | treatise on the flora of this vicinity, and for a new and

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revised catalogue of the plants. While there now exists a provisional catalogue containing most of the species which have been collected or observed by botanists during the past six or seven years, it consists of so many small annual accretions, due to constant new discoveries, and contains withal so many blemishes and imperfections, incident to its hasty compilation and irregular growth, that it has ceased, in great part, to meet the demands of the present time. The elaboration of a systematic catalogue of the local flora was not, however, at the outset at all contemplated, but merely the presentation of certain notes and special observations on particular species, which had been made in the course of some nine years of pretty close attention to the vegetation, and somewhat varied and exhaustive field studies in this locality.

The flowering-time of most species here is much earlier than that given in the manuals, and is, moreover, in many cases, very peculiar and anomalous, rendering it important to collectors as well as interesting to botanists to have it definitely stated for a large proportion of the plants. It being thus necessary to extend the enumeration so far, it was thought that the remainder might as well be added, thus rendering it a complete catalogue of all the vascular plants known to occur here at the present time. To these has been appended the list of *Musci* and *Hepaticæ* prepared by the late Mr. Rudolph Oldberg for the *Flora Columbiana*, which has been left unchanged except in so far as was required to make it conform strictly to Sullivant's work, which has long been the standard for this country. Dr. E. Foreman has also furnished the names of a few of the *Characeæ* collected by himself and named by Prof. Farlow, of Cambridge, which, in the present unsettled state of the classification of the cryptogams, have, for convenience, been placed at the foot of the series.

In undertaking this compilation I have endeavored to resist the usual temptation of catalogue makers to expand their lists beyond the proportions which are strictly war-

ranted by the concrete facts as revealed by specimens actually collected or species authentically observed; but have been content to set down only such as I can either personally vouch for, or as are vouched for by others who have something more substantial than memory to rely upon; preferring that a few species actually occurring but not yet seen should be omitted and afterwards supplied, rather than
66 that others, sup|posed to exist, but which cannot be found, should stand in the catalogue to be apologized for to those who would be glad to obtain them. A few species, however, which are positively known to have once occurred within our limits, but which have been obliterated within the recollection of persons now living, have been retained, as well as several of which only a single specimen has been found; but in all such cases the facts are fully stated in the notes accompanying each plant.

Range of the Local Flora.

The extent of territory which has of late years been tacitly recognized by botanists here as constituting the area of what has been called the *Flora Columbiana* is limited on the north by the Great Falls of the Potomac, and on the south by the Mount Vernon estate in Virginia, and Marshall's just opposite this on the Maryland side of the river, while it may reach back from the river as far as the divide to the east, and as far westward as the foot of the Blue Ridge, so as not to embrace any of the peculiarly mountain forms. Practically, however, the east and west range is much more restricted and only extends a few miles in either direction.

Comparison of the Flora of 1830 *with that of* 1880.

Washington and its vicinity has long been a field of botanical research. The year 1825 witnessed the dissolution of the *Washington Botanical Society*, which had for many years cultivated the science, and the same year also saw the formation of the *Botanic Club*, which continued

the work, and in one respect, at least, excelled the former in usefulness, since it has handed down to us of the present generation a valuable record in the form of a catalogue of the plants then known to exist in this locality. This catalogue, which was fittingly entitled *Floræ Columbianæ Prodromus*, and claimed to exhibit "a list of all the plants which have as yet been collected," though now rare, and long out of print, is still to be found in a few botanical libraries.

I have succeeded in securing a copy of this work, and have been deeply interested in comparing the results then reached with those which we are now able to present. A few of these comparisons are well worth reproducing.

It should be premised that the *Prodromus* is arranged on the | artificial system of Linnaeus, so that before the plants could be placed in juxtaposition they required 67 to be rearranged. This, however, was not the principal difficulty. Such extensive changes have taken place in the names of plants during the fifty years which have elapsed since that work appeared, (1830,) that it is only with the greatest difficulty that they can be identified. After much labor, I have succeeded in identifying the greater part of them, and in thus ascertaining about to what extent the two lists are in unison. This also reveals the extent to which each overlaps the other, and thus affords a sort of rude index to the changes which our flora has undergone in half a century. There are, however, as will be seen, many qualifying considerations which greatly influence these conclusions and diminish the value of the data compared.

The whole number of distinct names (species and varieties) enumerated in the *Prodromus* is 919. Of these 59 are mere synonyms or duplicate names for the same plant, leaving 860 distinct plants. I have succeeded in identifying 708 of these with certainty as among those now found, and six others, not yet clearly identified, should probably be placed in this class. This leaves 146 enumerated in the old catalogue which have not been found in recent

investigations. [A classified list of these plants was presented and commented upon somewhat in detail.]

With regard to these 146 species, it must not be hastily concluded that they represent the disappearance from our flora of that number of plants. While they doubtless indicate such a movement to a certain extent, there are ample evidences that many of them can be accounted for in other ways. After careful consideration, I have been able to divide them into four principal classes arising out of—

1st. Errors on the part of those early botanists in assigning to them the wrong names.

2d. The introduction into the catalogue of adventitious and even of mere cultivated species, never belonging to the flora of the place.

3d. The undue extension by those collectors of the range of the local flora so as to make it embrace a portion of the maritime vegetation of the Lower Potomac or the Chesapeake Bay, and also the mountain flora of the Blue Ridge.

4th. The actual extermination and disappearance of indigenous plants during the fifty years that have intervened since they made their researches.

68 | The assignment which I have made of each species to its appropriate class has been of course in great part conjectural and may be incorrect in many cases, while another botanist might have differed considerably in regard to special plants; yet it is not based on a general judgment drawn from my acquaintance with the present flora, but upon several kinds of special evidence, which in numerous instances has reversed my *prima facie* decision.

In the first place, I have carefully compared the range of each species as given in the text books to determine the probabilities for or against its being found here, and in the second place I have compared this list with the corresponding one of the species now found but not enumerated in the *Prodromus*. I have also endeavored to make due allowance on the one hand for the tendency above referred to to swell

catalogues beyond their proper limits, and on the other for the well known fact that every flora is at all times undergoing changes.

It must not be forgotten, either, that half a century ago the surface of the entire country here must have presented a very different appearance from that which it presents now. The population of the District of Columbia in 1830, when it included a portion of Virginia, was only 39,834. It is now, exclusive of the Virginian part receded to that State, 177,638. To render the comparison more exact we may add to the latter number the present population of Alexandria county, amounting to 17,545, and we have in the place of 39,834 a population on substantially the same area of 195,183, or about five times as large. The population of Maryland in 1830 was 447,040; in 1880 it was 934,632, or considerably more than twice as large. That of Virginia in 1830 was 1,211,405. Virginia and West Virginia, embracing the same territory, now number 2,131,249, the population not having quite doubled; the retardation, however, as compared with Maryland, is doubtless due entirely to influences affecting the southern counties. There were doubtless large areas of primeval forest then within our limits which are now under cultivation, and a much greater variety of soil and woodland was then open to the researches of the botanist. As a consequence we ought to expect that it would sustain a much richer flora.

The general result at which I arrive by the process adopted may be summed up as follows:

1st. That 43 of these names, or 29 per cent of them, belong to the first class and constitute errors in naming.

| 2d. That 12 of these plants, or 8 per cent, belong to the second class, or were simply cultivated species, and never belonged to this flora. 69

3d. That 10 of them, or 7 per cent, belong to the third class and were collected beyond the reasonable limits of our local flora.

4th. The remaining 81, or 56 per cent, belong to the fourth class, and represent *bona fide* discoveries in 1830 of species which either do not now occur or are so rare as to have escaped the investigations of the present generation of botanists.

With regard to the first of these classes, the large number of errors in naming cannot be considered any derogation from the ability or fidelity of the compilers of the *Prodromus* or their immediate predecessors, when we remember the very unsettled state that American botany was in at that time. Both names and authorities were badly confused, and errors were committed even by the most experienced botanists. For example, their *Corydalis glauca* as probably also their *C. aurea*, meant *C. flavula* which is now abundant, but omitted by them. Their *Arabis stricta* might have been *A. hirsuta* or *A. patens*, which are both now rare, though it was more probably a form of *A. laevigata*, as they seemed to be specially fond of drawing nice distinctions and expressing them by synonyms. Varieties, however, were scarcely recognized by them, the trinomial theory being then in its infancy. I might thus proceed to discuss all their supposed errors, but this is not necessary.

The second and third classes, amounting together to 16 per cent of the alleged excess over the present flora, consist also of errors, but errors which it is much less easy to palliate. It is natural to wish to make as large a showing as possible, and the temptation to insert into a catalogue everything which by any construction can be claimed to belong there is rarely resisted. To show that this propensity still exists, it may be remarked that of the 1054 species enumerated in the preliminary catalogue of plants of this vicinity, published by the Potomac Side Naturalists' Club in 1876, 89, or about 8½ per cent, are now admitted by all not to have been seen here at that time, and have never been found by any one since, although nearly three hundred other species have since been added to the flora. This is certainly not a scientific method to proceed upon, and as

already remarked, the present effort aims to eliminate to a great extent this source of error.

The 81 species constituting the fourth class remain, therefore, the | only ones to which any special interest attaches, and for the determination of which the present 70
somewhat laborious analysis of this ancient document has been undertaken. For these, the botanists of our times should make diligent search and perchance a few of them may still be found. Assuming that they no longer exist, they do not represent the whole number of plants that have disappeared from our flora during the interval of fifty years. This could be only on the assumption that the *Prodromus* was a complete record of the flora at the time. This it certainly is not. The aggregate number, exclusive of synonyms or duplicated names, which it contained was, as we saw, 860, which includes one cellular plant, viz., a *Chara*. We now identify, counting as was then done, species and varieties, 1249 distinct vascular plants. While no doubt many of these have been freshly appearing while others have been disappearing, still, from the considerations above set forth, it is highly probable that the indigenous flora of 1830 was considerably larger than that of 1880, and may have reached 1400 or 1500 vascular plants. It would appear, therefore, that only a little over half the plants actually existing were discovered by the botanists of that day, and enumerated in their catalogue. If the proportion of disappearances could be assumed to be the same for species not discovered as for those discovered by them, this would raise the aggregate number to considerably above one hundred, and perhaps to one hundred and twenty-five.

The great number of present known species not enumerated in the *Prodromus*, some of them among our commonest plants and amounting in the aggregate to 535 species, is another point of interest, since, after due allowance has been made for mistakes in naming them, it remains clear on the one hand that these researches must have been,

compared with recent ones, very superficial; and on the other, that, not to speak of fresh introductions, many plants now common must have then been very rare, otherwise they would have proved too obtrusive to be thus overlooked.

Localities of Special Interest to the Botanist.

The flora of a wild region is always more uniform than that of one long subjected to human influences. The diversity in the former is a natural consequence of the corresponding diversity in the surface and other physical features. In the latter it is due to condi|tions ar-
71 bitrarily imposed by man. A primeval flora is usually more rich in indigenous species, but the artificial changes caused by cultivation often offset this to a great extent by the introduction of foreign ones. This, however, greatly reduces its botanical interest.

In many respects the botanist looks at the world from a point of view precisely the reverse of that of other people. Rich fields of corn are to him waste lands; cities are his abhorrence, and great areas under high cultivation he calls "poor country;" while on the other hand the impenetrable forest delights his gaze, the rocky cliff charms him, thin-soiled barrens, boggy fens, and unreclaimable swamps and morasses are for him the finest lands in a State. He takes no delight in the "march of civilization;" the ax and the plow are to him symbols of barbarism, and the reclaiming of waste lands and opening up of his favorite haunts to cultivation he instinctively denounces as acts of vandalism. In him more than in any other class of mankind the poet's injunction—

"Woodman, spare that tree,"

touches a responsive chord. While all this may seem as absurd to some as does the witholding from tillage of great pleasure grounds in the form of hunting parks for

the landed sporting gentry of Northern and Western Europe, still, when these parts of the world are compared with the artificially made deserts of Southeastern Europe and Western Asia, caused by the absence of such sentiments, there may, perhaps, be dimly recognized a "soul of good in things evil," if not a soul of wisdom in things ridiculous.

After the protracted subjection of a country to the conditions of civilization it gradually comes about that while the greater part of the surface falls under cultivation, more or less thorough, and the botanist is ultimately excluded from it, there will remain a few favored spots, which, from one cause or another, will escape and continue to form his favorite haunts. In the vicinity of large rivers, giving greater variety to the surface, or of rugged hills or mountains, this will be especially the case. As a country grows old large estates in the vicinity of cities fall into the possession of heirs who are engaged in mercantile or professional business, and neglect them, or they come into litigation lasting for years, and are thus happily abandoned to nature. These and other causes have operated in an especial manner in the surroundings of Washington, and there thus exist a large number of these green oases, as it were, interspersed over the otherwise botanical desert. 72

In consequence of this fact it requires experience in order to improve the facilities which the place affords. A botanist unacquainted with the proper localities for successful collection might spend a month almost in vain, and depart with the conviction that there was nothing here to be found. It may not be wholly peculiar, but these favored localities are here often of very limited extent, and in situations which from a distance afford no attraction to the collector. Civilization is, however, very perceptibly encroaching upon many of them, and it is feared that in another half century little will be left but a few bare rocks or inaccessible marshes.

In naming localities the principal authorities relied upon are: 1. A recent *Atlas of fifteen miles around Washington*,

including the County of Montgomery, Md., Compiled, Drawn, and Published from Actual Surveys, by G. M. Hopkins, C. E: Philadelphia, 1879; and, 2, a military map of Northeastern Virginia, published in the work of General J. G. Barnard, on the *Defences of Washington*, 1821.

From the former the names of many roads, streams, estates, &c., have been obtained, while from the latter those of forts, batteries, &c., are often employed as more convenient. In this respect, however, much remains to be desired. While the military map is antiquated, the other is frequently defective in omitting what is required and incorrect in erroneously locating streams and other objects well known to the writer. In his extensive rambles he has learned many local names not found on the map, and in a few cases of special botanical interest, where names are wholly wanting, he has long been in the habit of designating the localities by names of his own christening, and for which he offers no apology.

The following are a few of the principal places of botanical interest which will be found to recur most frequently in the notes, and for this reason brief descriptions of them are appended.

1. *The Rock Creek Region.*—Rock Creek, which forms the boundary line between Washington and Georgetown (West Washington), has escaped to a remarkable degree the inroads of agriculture and population. For the greater part of its length within the District of Columbia its banks are still finely wooded for some distance back, and afford a rich and varied field for botanical exploration. The character of the surface along Rock Creek is most beautiful and picturesque, often rocky and hilly with fre-
73 quent deep ravines | coming down into the usually narrow bottom through which the creek flows. The stream itself is full of the most charming curves and the whole region is an ideal park. No one can see it without thinking how admirably it is adapted for a National Park. Such a park might be made to extend from Oak Hill Cemetery to the

Military Road opposite Brightwood, having a width of a mile or a mile and a half. Not only every botanist but every lover of Art and Nature must sigh at the prospect, now not far distant, of beholding this region devastated by the ax and the plow. The citizens of Washington should speedily unite and strenuously urge upon Congress the importance of early rescuing this ready-made National Park from such an unfortunate fate.*

The Rock Creek Region is divided, so far as the designation of localities is concerned, into six sections. The first embracing the series of groves from Georgetown to Woodley Park on the right bank of the creek, is called Woodley. This section embraces several interesting ravines and in it are found many plants rare elsewhere, such as *Chamælirium Carolinianum*, *Cypripedium pubescens*, *Hesperis matronalis* and *Liparis Læselii*. In it is also a grove of the Hercules' club (*Aralia spinosa*.) On the left bank of the creek lie the Kalorama Heights and some open woodland.

The *Woodley Park* section extends to the ravine which comes down opposite the old brick mill-ruin known as the Adams Mill. The timber here has been thinned out recently by the proprietors but not cleared off, and the vegetation has undergone a marked change. Several interesting plants have been found in Woodley Park, including the rare *Obolaria Virginica*, and the beautiful *Spiraea Aruncus*. Above this the timber is heaviest on the left bank and some very fine ravines occur, at the head of one of which is a magnolia and sphagnum swamp where *Veratrum viride*

*It is remarkable that when committees of Congress have been appointed, as has several times been done, to consider a site for a National Park, they have usually looked in other directions and have seemed to ignore the existence of this region, which is certainly the only one that possesses any natural claims. A mere carriage ride through such parts as are traversed by roads is wholly insufficient to afford an adequate idea of its merits from this point of view. For the greater part of the distance mentioned above this region is accessible only to footmen.

and *Symplocarpus fœtidus* keep company with *Gonolobus obliquus* and *Pyrus | arbutifolia*. Here, too, though
74 well up towards the ford, has been found *Polemonium reptans*, not seen elsewhere.

This third section terminates at Piney Branch, and from here to Pierce's mill, and as far above as the mouth of Broad Branch, the fourth section extends. This section is well wooded on both sides and includes the enchanting Cascade run which leaps down over the most romantic rocks. Near Pierce's mill are many trees and shrubs, planted there years before, but now well naturalized. Among these are *Aralia spinosa*, *Xanthoxylum Americanum*, *Acer saccharinum*, *Pinus Strobus*, and *Carya alba*. Below the mill on the creek bottom is a long-abandoned nursery of *Populus alba* and *Acer dasycarpum*, from which many of the trees of the city may have been supplied.

From Broad Branch to the Military road is the fifth and perhaps most interesting section of the Rock Creek Region. On the left bank lie the once noted Crystal Springs, and though the buildings are removed, the springs remain unchanged. Here have been found *Ophioglossum vulgatum*, *Anychia dichotoma*, and *Perilla ocimoides*, as well as *Tipularia discolor*. On the right bank and above Blagden's mill is a bold bluff in a short bend of the creek forming a sort of promontory upon which there grows *Gaultheria procumbens*, the winter-green or checkerberry, this being its only known locality within our limits. Half a mile farther up and back upon the wooded slope is the spot on which stand a dozen or more fine trees of the Table Mountain Pine (*P. pungens*). Here also was first found *Pycnanthemum Torreyi*.

To these there must be added a sixth section extending from the Brightwood road to the north corner of the District of Columbia which lies near Rock Creek. For the first mile there is little of interest, the cultivated land approaching the creek and the low hills near its banks being covered with a short second growth of scrub pine and black-jack.

But above the Claggett estate on the right bank, and to some extent on both sides, lies the largest forest within our limits. This wood belongs, I learn, to the Carroll estate, and is so designated in this catalogue. In it have been found very many most interesting plants. It was the first extensive tract found for the crowfoot (*Lycopodium complanatum*) and still constitutes the most reliable and abundant source known of this plant. Its present fame, however, rests upon its hybrid oaks, of which some most interesting forms have been found there. [See Field and Forest, | October and November, 1875; Botanical Gazette, October, 1880, p. 123.] Here also grows 75
very sparingly *Microstylis ophioglossoides*, and quite abundantly *Pyrola elliptica* and *P. secunda*. It is also a rich locality for many other species rare elsewhere.

2. *The Upper Potomac Region.*—The flora of the left bank of the Potomac is, in many respects, very unlike that of any other locality within our limits. A mile above Georgetown, and commencing from the recently constructed outlet lock of the Chesapeake and Ohio canal, there exists a broad and low strip of country formerly known by the name of Carberry Meadows, lying between the canal and the river, and extending to the feeder of the canal, a distance of about three and a half miles. This interval is relieved by two convenient landmarks, viz., one mile above the outlet lock, a grist-mill and guano factory, popularly known as Eads' mill; and a mile further, the celebrated Chain Bridge. Little Falls, proper, begin a hundred yards above the bridge, and extend half a mile or more. The region above the bridge will, therefore, be designated as Little Falls. The flats terminate in a remarkable knoll or small hillock of very regular outline and abrupt sides, which, from the combined effects of the feeder on one side, and large overflows from it below, becomes practically an island, and is well known to all as High Island. These river flats are, in most places, covered with large boulders of the characteristic gneiss rock of the country. In some parts

the surface is very rough, and numerous pools or small ponds of water occur. Overflows and leakages from the canal cause large sloughs and quagmires, while annual ice-gorges crush down the aspiring fruticose vegetation. All these circumstances lend variety to the locality, and, as might be expected, the flora partakes largely of this characteristic. It would prolong this sketch unduly to enumerate all the rare and interesting plants which this region has contributed to our vegetable treasures, but conspicuous among them are *Polygonum amphibium*, var. *terrestre*, *Isanthus cæruleus*, *Herpestis nigrescens*, *Brasenia peltata*, *Cyperus virens*, and *Nesæa verticillata*, all of which occur below Eads' mill; *Ammannia humilis*, a remarkable variety of *Salix nigra*, (*S. nigra* var. *Wardi*, *Bebb*) *Salix cordata*, and *S. longifolia;* as also *Spiranthes latifolia*, and *Samolus Valerandi*, var. *Americanus*, *Vitis vulpina* and *Panicum pauciflorum*, which may be found between this point and the bridge, while at the Little Falls we are favored with *Paronychia dichotoma*, *Œnothera fruticosa*, var. *lineare*
76 |(very distinct from the type) and *Ceonothus ovatus;* also *Ranunculus pusillus* and *Utricularia gibba*. But rich and varied as are these lower flats, they are excelled by High Island, the flora of which is by far the most exuberant of all within the knowledge of botanists. Here we find *Jeffersonia diphylla*, *Caulophyllum thalictroides*, *Erigenia bulbosa*, *Silene nivea*, *Valeriana pauciflora*, *Erythronium albidum*, *Iris cristata*, and a great number of others of our most highly prized plants, many of which are found nowhere else.

Above the feeder is a series of islands in the river lying for the most part near the Maryland shore, and to which the maps, so far as I can learn, assign no names. The first of these lies well out in the river, and has been made to form a part of the feeder-dam. It is low and frequently overflowed, and has not, as yet, furnished many rare plants, though here *Arabis dentata* and some others have been found. It has been designated *Feeder-dam Island*. The second is half or three-quarters of a mile above, lies higher, and is

covered with a very dense and luxuriant herbaceous vegetation and fine trees, chiefly of Box Elder, *Negundo aceroides*, from which circumstance and the peculiar impression which the long gracefully pendent staminate flowers of these trees produced on the occasion of its first discovery by a botanical party, it received the name of *Box Elder Island*. The third island is a short distance above the last, has a more elevated central portion and a similar vegetation. Here was found, on our first visit, and also on subsequent ones, *Delphinium tricorne*, and for this contribution to the Flora Columbiana it was christened *Larkspur Island*. The fourth of these islands is, in many respects similar to the two last described, and upon it stands the only indigenous specimen of *Acer saccharinum* yet found here. It has, therefore, been appropriately named *Sugar-maple Island*. *Erythronium albidum*, *Trillium sessile*, *Jeffersonia diphylla* and similar species abound on all these islands, while on the Larkspur Island, besides the *Delphinium*, has also been found *Phacelia Purshii*. The beauty of these natural flower-gardens in the months of April and May is unequaled in my experience. The light and rich alluvial soil causes the vegetation to shoot up with magic rapidity at the first genial rays of the vernal sun, and often the harbinger of spring, *Erigenia bulbosa*, true to its name, will greet the delighted rambler in late February or early March.

The opposite, or Virginia side of the Upper Potomac consists entirely of bold bluffs, interrupted by deep ravines, often contain|ing wild torrents and dashing cascades. 77
Here the flora, though less rich and varied, is also characteristic and interesting, and embraces, among other rare things, *Rhododendron maximum*, *Iris cristata*, *Scutellaria saxatilis*, *Pycnanthemum Torreyi*, *Solidago rupestris* and *S. virga-aurea*, var. *humilis*. On the Maryland side and a mile above the uppermost point thus far mentioned, is the Cabin John run, which the botanist celebrates more for its walking fern (*Camptosorus rhizophyllus*) than for the world-renowned arch that spans it.

The next most prolific source of interesting plants is the region of the Great Falls. The collecting grounds begin a mile or more below at Broad Water. On both sides of the canal the country is excellent, rocky and wooded, with stagnant pools and sandy hillocks. On these rocks grow *Sedum telephioides* and near Sandy Landing are found *Vitis vulpina*, *Arabis patens*, *A. hirsuta* and *Triosteum angustifolium*. In the pools have been found *Carex decomposita*, *Potamogeton hybridus* and *P. pauciflorus*, while on a rocky headland a large "water-pocket" has yielded my only specimen of the white water lily (*Nymphæ aodorata*). *Cratægus parvifolia*, *Rumex verticillatus*, *Steironema lanceolatum*, and last but not least, *Nasturtium lacustre*, have also rewarded my researches in this singular and rather weird region.

On the opposite side of the river the site of the ancient canal around the Falls has proved very fertile in botanical trophies. *Polygala ambigua* is found near the boat landing, while by climbing the cliffs below this point the native of more northern climes may gaze once more upon his familiar Hemlock Spruce, *Tsuga Canadensis*. Difficult Run, a mile farther down, though indeed difficult of approach, repays the effort with *Podostemon ceratophyllus*, *Smilacina stellata*, *Potamogeton Claytonii*, and numerous other herbal treasures.

3. *The Lower Potomac Region.*

Passing next to the lower Potomac, the localities of special interest are: 1. Custis Spring, opposite the Arlington estate, with the extensive marsh below, where *Sagittaria pusilla*, *Discopleura capillacea*, *Cyperus erythrorhizos*, and other rare species are alone known to grow. 2. The point and bay below Jackson City, known as Roach's run, where are found, among others, *Scrophularia nodosa*, |*Tripsacum dactyloides*, and *Pycnanthemum lanceolatum*.
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3. Four Mile run, half way to Alexandria, not yet sufficiently explored, including the vicinity of Fort Scott to

the northwest, where *Clematis ochroleuca* and *Asclepias quadrifolia* may be collected; and, 4. Hunting creek, a large estuary below Alexandria, including Cameron run, the stream which debouches into it, with its tributaries, Back Lick run and Holmes run, which unite to form it. Here have been found, at various points, *Clematis ochroleuca*, *Gonolobus hirsutus*, *Itea Virginica*, *Geranium columbinum*, *Micranthemum Nuttallii*, *Habenaria virescens*, *Quercus macrocarpa*, *Carex gracillima*, *Geum strictum*, *Galium asprellum*, and very many other rare plants.

On the left bank of the lower Potomac the chief locality of interest is a large wooded area below the Government Hospital for the Insane. This has proved a rich hunting ground for the botanist, and has yielded *Carex pallescens*, *Carex Woodii*, *Gonolobus hirsutus*, *Silene Armeria*, *Parietaria Pennsylvanica*, *Myosotis arvensis*, *Scutellaria nervosa*, &c., &c. *Asplenium angustifolium* is known only at Marshall Hall, where it has been reported by Mr. O. M. Bryan, while opposite Fort Foote Mr. Zumbrock has found *Myriophyllum spicatum*, and opposite Alexandria Professor Comstock and Miss Willets have discovered *Plantago cordata*.

4. *The Terra Cotta Region.*

This embraces some low grounds and undulating barrens near the terra cotta works, at Terra Cotta Station, on the Metropolitan Branch of the Baltimore and Ohio railroad, three miles from the city, and also a small swamp a quarter of a mile beyond, and to the eastward. Here on the dry ground have been found *Onosmodium Virginianum*, *Lespedeza Stuvei*, *Clitoria Mariana*, and *Habenaria lacera;* and in the swamp *Aster æstivus*, *Solidago stricta*, *Woodwardia Virginica*, *Asclepias rubra*, *Poterium Canadense*, and numerous other plants rare or absent in other localities.

5. *The Reform School Region.*

This locality is very limited in extent, but has proved one of the most fertile in botanical rarities. Its nucleus consists

of a little swampy spot a short distance to the south of the National Reform School, in which is located a beautiful spring; but the woody|tract of country surrounding this
79 and stretching southward and eastward some distance has also proved very fruitful. In the different portions of this region have been discovered *Phlox maculata*, *Melanthium Virginicum*, *Bartonia tenella*, *Lespedeza Stuvei*, *Desmodium Marylandicum* and *D. ciliare*, *Buchnera Americana*, *Fimbristylis capillaris*, *Quercus prinoides*, *Carex bullata*, and *Gentiana ochroleuca*, most of which do not occur at all elsewhere.

6. *The Holmead Swamp Region.*

Like the last, this locality is quite circumscribed in area, but like it, too, it is rich in interesting plants. It occupies a ravine leading to Piney Branch from the east at the point where the continuation of Fourteenth street crosses that stream. The road connecting the last named with the Rock Creek Church road, and which is called Spring street, follows this valley. The collecting grounds are on the south side of this road and in the springy meadow along the rill. The timber has long been cut off, but the boggy character of the ground has thus far protected it from cultivation. The pasturing of animals on it during a portion of the year has latterly become a serious detriment to the growth of plants. Mr. Holmead, who owns it and lives near by, has kindly permitted botanists to investigate it for their purposes. Here have been found *Ludwigia hirsuta*, *Drosera rotundifolia*, *Asclepias rubra*, *Xyris flexuosa*, *Fuirena squarrosa*, *Rhynchospora alba*, *Coreopsis discoidea*, and the beautiful *Calopogon pulchellus*, the most showy of our orchids.

In addition to these specially fertile tracts there are many other localities of great interest where valuable accessions to our flora have been made, and which will be particularly designated under the names of these species. It will suffice here to mention a wet meadow between the National

Driving Park and Bladensburg, where, in a very diminutive spot, *Sarracenia purpurea*, *Viola lanceolata*, and *Carex bullata*, the two first wholly unknown elsewhere, have been discovered; a marsh a mile from Bladensburg, near the mill-race, where only the majestic *Stenanthium robustum* has been seen; a little swamp near the Sligo creek, between the Riggs and Blair roads, where the Hartford fern (*Lygodium palmatum*) grows sparingly; and another between Bladensburg and the Maryland Agricultural College where *Solidago elliptica*, *Ascyrum stans*, and *Lycopodium complanatum*, var. *Sabinæfolium*, have been found. The Eastern branch region is not specially rich in floral treasures, but on its banks and marshes some good things appear. *Habenaria virescens*, *Steironema lanceolatum*, *Eleocharis quadrangulata*, *Scirpus fluviatilis*, *Ranunculus ambigens*, and *Salix Russelliana* are among these, though some of them are found elsewhere. 80

Flowering Time of Plants.

It has already been remarked that most species flower at Washington much earlier than at points farther north or the dates given in the manuals. In consequence of this, a botanist unacquainted with this fact, and accustomed to those climates and to relying upon the books, would be likely to be behind the season throughout the year, and fail to get the greater part of the plants he desired. With all my efforts to make allowance for this fact, I have frequently been sorely disappointed and was at last driven to making a careful record, preserving and correcting it from year to year, of the *flowering time* of plants in this locality. The notes on this subject appended to nearly every species enumerated in the list embody the general results of these observations and may in the main be relied upon. The expressions used are not loose conjectures, but are in the nature of compilations from recorded data. In most cases an allowance of two weeks may be made for the difference

in seasons though rarely more and often less. Certain plants, as for example, *Tipularia discolor*, flower at almost exactly the same time every year. Occasionally, however, one will vary a month or more in a quite unaccountable way. But any one who has watched the periodical changes of the general vegetation for a series of years and recorded his observations, will more and more realize the exactness even of these complex biological phenomena which depend so absolutely upon uniform astronomical events.

From this point of view the season which presents the greatest variation, and also, for this and other reasons, the greatest interest is the spring. There are a few plants which may sometimes be found in flower here in January, such as *Stellaria media*, *Taraxacum Dens-leonis*, or *Acer dasycarpum* (collected Jan. 17, 1876, in the city) in favored places, but these will bloom at any time when a few days of mild weather with sunshine can come to revive them. There are, however, several strictly vernal species which bloom quite regularly in the latter part of February, such as *Symplocarpus fœtidus*, *Chrysosplenium Americanum*, and often *Anemone Hepatica*. The number regularly found in flower in March is quite large and in special years very large. It was of course impossible to make observations every day of any year, but taking a number of years my observations cover nearly every day of the spring season. As showing the number of these early vernal species and also how widely the seasons may differ, the following facts are presented:

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In the year 1878 seventeen species had actually been seen in flower and noted up to March 24th. I did not go out again that year until April 7, when I enumerated forty-six additional species, making sixty-three in all up to that date. This was an exceptionally early season. The next spring, that of 1879, was a backward one, as is shown by the fact that while I had visited the same localities, and taken notes

with equal care only thirty-three species had been seen in flower up to April 13th: twenty-nine species which had been seen in flower on April 7th, 1878, were not yet in flower in the same localities on April 13th, 1879. There appeared to be about three weeks' difference in these two seasons. The last season, 1880, was again an early one, though less so than 1878. It was, however, near enough to the average to render the facts observed of great value. The following are a few of them: On February 29th, seven species were seen in flower in the Rock Creek region. On April 4th, thirty were enumerated on the Virginia side of the Potomac, above the Aqueduct Bridge. On April 11th, eleven were seen in addition to those previously enumerated in the Eastern Branch region; and on the 18th of April, High Island was visited, and twenty-nine added to all previously recorded, three of which were then in fruit. The total to this date was therefore seventy species. This season I concluded was a week or ten days later than that of 1878, and as much earlier than that of 1879.*

|We may now inquire what some of these early plants are. The following have been observed in flower in February: 82

* Since the above was written the present season (1881) has passed its vernal period. It has proved still more backward than 1879 and the latest spring thus far observed. On April 3d, I made my first excursion and visited the Virginia side of the Potomac above Rosslyn. Only 7 species were seen in flower including *Alnus serrulata* which doubtless can be obtained much earlier in ordinary years, but has been overlooked. Besides *Draba verna*, a January species, and *Anemone Hepatica*, a February one, the only herbaceous flower found was *Sanguinaria Canadensis*. On April 10th, High Island was visited, but only 8 species could be added to the above 7, and several of these, as *Jeffersonia diphylla*, *Dicentra Cucullaria*, *Saxifraga Virginiensis*, *Erythronium Americanum* and *Stellaria pu|bera*, were very sparingly out. Cold weather continued to the end of the third week in April, and on April 24th, 82 when High Island was again visited and a thorough canvass made, only 22 additional plants could be found there, and the whole number seen to that date was 46. The conclusion was that up to that time the season was about three weeks later than that of 1880.

Chrysosplenium Americanum, February 17, 1878.
Anemone Hepatica, February 20, 1876.
Salix Babylonica, February 22, 1874.
Populus alba, February 22, 1874.
Draba verna, February 24, 1878.
Acer dasycarpum, February 24, 1878.
Stellaria media, February 29, 1880.
Cerastium viscosum, February 29, 1880.
Claytonia Virginica, February 29, 1880.
Acer rubrum, February 29, 1880.
Symplocarpus fœtidus, February 29, 1880.

To these should, perhaps, be added *Equisetum hyemale*, which was found February 17, 1878, near the receiving reservoir with the spikes well advanced, quite contrary to the books which make it fruit in summer.

In addition to the above, which may often also be seen later, the following have been noted flowering in March:

Populus alba, March 3, 1874.
Viola pedata, March 5, 1876.
Houstonia cœrulea, March 5, 1876.
Obolaria Virginica, March 5, 1876.
Dentaria heterophylla, March 8, 1874.
Poa brevifolia, March 8, 1874.
Capsella Bursa-pastoris, March 10, 1878.
Lamium amplexicaule, March 10, 1878.
Lindera Benzoin, March 10, 1878.
Epigaea repens, March 15, 1874.
Ulmus fulva, March 15, 1874.
Luzula campestris, March 15, 1874.
Saxifraga Virginiensis, March 16, 1879.
Sanguinaria Canadensis, March 17, 1878.
Sisymbrium Thaliana, March 17, 1878.
Salix tristis, March 17, 1877.
Populus grandidentata, March 21, 1880.
Corydalis flavula, March 22, 1874.

Thalictrum anemonoides, March 24, 1878.
Dentaria laciniata, March 24, 1878.
Antennaria plantaginifolia, March 24, 1878.
Erodium cicutarium, March 27, 1874.
Erigenia bulbosa, March 28, 1875.
Cardamine hirsuta, March 30, 1879.

It is about the first of April, especially in early years, that the vegetation seems to receive the greatest impetus. This is well shown by the following list of species seen in flower during the first week in April:

Ulmus Americana, April 1, 1873.
Jeffersonia diphylla, April 2, 1876.
Cardamine rhomboidea, April 2, 1876.
Stellaria pubera, April 2, 1876.
Thaspium aureum, April 2, 1876.
Euphorbia commutata, April 2, 1876.
Alnus serrulata, April 3, 1881.
Ranunculus abortivus, April 4, 1880.
Dicentra Cucullaria, April 4, 1880.
Arabis laevigata, April 4, 1880.
Viola tricolor, var. arvensis, April 4, 1880.
Vicia Caroliniana, April 4, 1880.
Amelanchier Canadensis, April 4, 1880.
Nepeta Glechoma, April 4, 1880.
Sassafras officinale, April 4, 1880.
Carpinus Americana, April 4, 1880.
Ostrya Virginica, April 4, 1880.
Erythronium Americanum, April 4, 1880.
Barbarea vulgaris, April 5, 1874.
Pedicularis Canadensis, April 5, 1874.
Mertensia Virginica, April 5, 1874.
Ranunculus abortivus, var. micranthus, April 7, 1878.
Ranunculus repens, April 7, 1878.
Asimina triloba, April 7, 1878.
Caulophyllum thalictroides, April 7, 1878.

Arabis dentata, April 7, 1878.
84 |Barbarea praecox, April 7, 1874.
Sisymbrium Alliaria, April 7, 1878.
Viola cucullata, April 7, 1878.
Viola striata, April 7, 1878.
Viola glabella, April 7, 1878.
Ionidium concolor, April 7, 1878.
Silene Pennsylvanica, April 7, 1878.
Cerastium vulgatum, April 7, 1878.
Cerastium oblongifolium, April 7, 1878.
Geranium maculatum, April 7, 1878.
Oxalis corniculata, var. stricta, April 7, 1878.
Cercis Canadensis, April 7, 1878.
Potentilla Canadensis, April 7, 1878.
Thaspium trifoliatum, April 7, 1878.
Cornus florida, April 7, 1878.
Chrysogonum Virginianum, April 7, 1878.
Senecio aureus, April 7, 1878.
Fraxinus viridis, April 7, 1878.
Phlox divaricata, April 7, 1878.
Lithospermum arvense, April 7, 1878.
Betula nigra, April 7, 1878.
Populus monilifera, April 7, 1878.
Arisaema triphyllum, April 7, 1878.
Erythronium albidum, April 7, 1878.
Trillium sessile, April 7, 1878.

My special observations on the vernal flowering time of plants extend about two weeks later or to the end of the third week in April, after which the great number of plants in bloom, including the amentaceous trees, renders it difficult to pursue the investigation, while at the same time the facts become less valuable. The results for the second and third weeks of April, always excluding all previously enumerated, are as follows:

Arabis lyrata, April 9, 1876.

Fraxinus pubescens, April 11, 1880.
Salix cordata, April 11, 1880.
Salix purpurea, April 11, 1880.
Vaccinium corymbosum, April 12, 1880.
Carex platyphylla, April 12, 1880.
Poa annua, April 12, 1874.
|Thalictrum dioicum, April 14, 1876.
Rhus aromatica, April 14, 1878. 85
Phlox subulata, April 14, 1878.
Arabis patens, April 18, 1880.
Cardamine hirsuta, var. sylvatica, April 18, 1880.
Negundo aceroides, April 18, 1880.
Erigeron bellidifolius, April 18, 1880.
Krigia Virginica, April 18, 1880.
Sisyrinchium Bermudiana, April 18, 1880.
Carex laxiflora, April 18, 1880.
Carex Emmonsii, April 18, 1880.
Melica mutica, April 18, 1880.
Anemone nemorosa, April 19, 1874.
Viola cucullata, var. cordata, April 19, 1874.
Dirca palustris, April 19, 1874.
Carex Pennsylvanica, April 19, 1874.
Lathyrus venosus, April 21, 1878.
Ribes rotundifolia, April 21, 1878.
Salix nigra, var. Wardi, April 21, 1878.

We thus see that a single collector has in the course of eight years' operations actually observed and noted eleven species in bloom in February, 24 more in March, 51 additional in the first week of April, and 26 others during the second and third weeks of April or 112 up to April 21.

It should be remarked that there is no doubt that if the same localities in which the large numbers were observed on April 2, 1876, April 4, 1880, and April 7, 1878 had been visited in the last days of March of those years quite a number of these plants would have been found sufficiently advanced to demand a place in the lists, and thus the

month of March would have been credited with so many here set down for the first week in April. Probably, all things considered, not less than fifty species in certain favored seasons either reach or pass by their flowering-time by the end of March.

In arranging the above lists the order of dates has of course taken precedence, but where several are enumerated under one date the natural order is followed.

It is scarcely necessary to suggest a caution to collectors against relying upon these dates in making collections. They represent the earliest observations and not the average. In most cases an allowance of at least one week should be made for the full bloom|ing of all the individuals of any given species. In all cases, however, one or more individuals were actually seen in flower and sufficiently advanced for collection, otherwise no note was taken. The *Carices* of course had not advanced to developed perigynia, and many plants whose inflorescence is centrifugal or centripetal, or which develop fruit while retaining their flowers, should be looked for at a later stage.

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Autumnal Flowering.

One of the most interesting peculiarities of the flora of this vicinity is that of the second-blooming of vernal species, which in most cases takes place quite late in the fall. [See *Field and Forest*, April–June, 1878, Vol. III, p. 172.] In addition to the seven species observed and published in 1878, I have noted more than as many others manifesting this habit, and it is probable that still others will yet be added. The following is a list of those thus far recorded with the dates at which they were observed and which may be compared with those of their regular vernal period:

Ranunculus abortivus, var. micranthus, November 28, 1875.

Cardamine hirsuta, October 3, 1880.
Viola pedata, var. bicolor, September 22, and December 8, 1878.
Viola striata, September 10, 1876.
Fragaria Virginiana, September 22, 1878.
Rubus villosus, September 22, and October 27, 1878.
Lonicera Japonica, October 13, 1878.
Houstonia purpurea, October 13, 1878.
Houstonia purpurea, var. angustifolia, September 12, 1880.
Houstonia cærulea, September 7, 1879.
Vaccinium stamineum, October 13, 1878.
Rhododendron nudiflorum, October 13, 1878.
Sabbatia angularis, October 27, 1878.
Phlox divaricata, October 16, 1873.
Echium vulgare, October 8, 1880.
Veronica officinalis, October 8, 1873.
Agrostis scabra, November 12, 1876.

To this list of seventeen should perhaps be added *Stellaria pubera*, which instead of a vernal and autumnal period, has two vernal periods as described under that species in the systematic notes. | *Salix longifolia* has this year (1881) flowered twice; once in April and again in June. 87

Autumnal blooming, in so far as it is peculiar to this climate, may be chiefly attributed to the tolerably regular occurrence here of a hot and dry season in midsummer. This usually begins towards the end of June and ends about the middle of August. During this period, in some seasons, the ground and vegetation become parched and dried up, so that vegetal processes in many plants cease almost as completely as in the opposite season of cold. From this dormant state the warm and often copious rains of the latter part of August revive them, as do the showers of spring, and they begin anew their regular course of changes. The frosts of October usually cut their career short before

maturity is reached, but in some cases two crops of seed are produced. In addition to this, there frequently also occurs a very warm term in November, often extending far into December, and of this certain species take advantage and push forth their buds and flowers.

Albinos.

Well defined albinos have been collected of the following species:

Desmodium nudiflorum.
Liatris graminifolia.
Rhododendron nudiflorum.
Vinca minor.
Mertensia Virginica.
Sabbatia angularis.
Pontederia cordata.

The green flowered variety of *Trillium sessile* is also common, and *Gonolobus obliquus* exhibits on High Island this same anomalous feature. *Carex tentaculata* having the spikes perfectly white, as if etiolated, was found June 14 of this year (1881), on the Eastern Branch marsh. This last phenomenon was certainly due neither to maturity nor disease, but was a mere *lusus naturæ*.

Double Flowers, &c.

Thalictrum anemonoides, *Ranunculus bullosus*, *Claytonia Virginica*, and *Rubus Canadensis*, have been found with the flowers much doubled as in cultivation.

88 *Hydrangea arborescens* occasionally has the outer circle of petals expanded as in cultivation.

Rudbeckia fulgida has been found with all its rays tubular but of the usual length.

Statistical View of the Flora.

In order to present a clear view of the general character of the vegetation of the District of Columbia and the adjacent country, I have made a somewhat careful analysis of the large groups and families, and comparison of them not only with each other, but with the same groups and families in larger areas and other local floras. The general results are presented below.

It is important to remark that in all enumerations, it is not simply the number of *species*, as at present recognized, but the number of *different plants* (species and varieties), that is employed. The reason for doing this is that in very many cases well-marked varieties are eventually made species, and if two plants really differ there is little probability that they will ever be merged into one species without that difference being indicated by some difference of name. The aim has therefore been to take account of the number of plants without regard to the manner in which they are named.

The whole number of vascular plants now known to this flora, as catalogued in the list appended to this paper, is 1249, and these belong to 527 different genera, or about $2\frac{1}{3}$ species to each genus. These are distributed among the several systematic series, classes, and divisions, as follows:

Groups.	Genera.	Species and varieties.
Polypetalæ	174	356
Gamopetalæ	169	389
Total Dichlamydeæ	343	745
Monochlamydeæ (Apetalæ)	47	124
Total Dicotyledons	390	869
Monocotyledons	112	331
Gymnospermæ (Coniferæ)	4	7
Total Phænogamia	506	1,207
Cryptogamia	21	42
Total vascular plants	527	1,249

89 |The percentages of the total are as follows:

Polypetalæ	33	29
Gamopetalæ	32	31
Total Dichlamydeæ	65	60
Monochlamydeæ (Apetalæ)	9	10
Total Dicotyledons	74	70
Monocotyledons	21	26
Gymnospermæ (Coniferæ)	1	1
Total Phænogamia	96	97
Cryptogamia	4	3

Large Orders.

The sixteen largest orders arranged according to the number of species, are as follows:

	Genera.	Species and varieties.
1. Compositæ	53	149
2. Gramineæ	43	110
3. Cyperaceæ	10	108
4. Leguminosæ	24	57
5. Rosaceæ	15	46
6. Labiatæ	23	42
7. Cruciferæ	16	33
8. Scrophulariaceæ	15	32
9. Filices	16	30
10. Ranunculaceæ	7	27
11. Ericaceæ	11	26
12. Cupuliferæ	7	26
13. Orchidaceæ	12	24
14. Liliaceæ	18	24
15. Polygonaceæ	3	23
16. Umbelliferæ	17	22

The whole number of systematic orders represented in our District is 116, of which sixteen, or 14 per cent, furnish 55 per cent of the genera and 62 per cent of the species.

90 |*Large Genera.*

The fifteen large genera arranged according to the number of plants are the following:

	Species and varieties.
1. Carex	70
2. Aster	21
3. Panicum	19
4. Solidago	18
5. Quercus	18
6. Polygonum	16
7. Desmodium	14
8. Salix	14
9. Juncus	14
10. Viola	13
11. Cyperus	12
12. Ranunculus	11
13. Eupatorium	11
14. Helianthus	10
15. Asclepias	10

Thus fifteen, or less than three per cent, of the genera furnish 271, or nearly 22 per cent of the species.

Introduced Species.

The whole number of introduced plants enumerated in the subjoined catalogue is 193, of which 15 are supposed or known to be indigenous to other parts of the United States.* These are distributed through the several larger groups as follows:

	Old World.	United States.	Total.	
Polypetalous	65	8	73	91
Gamopetalous	54	3	57	
Apetalous	28	2	30	
Monocotyledonous	31	1	32	
Coniferous	—	1	1	
Total	178	15	193	

*These are the following:

Xanthoxylum Americanum.
Trifolium repens.
Prunus Chicasa.
Rosa setigera.
Philadelphus inodorus.
Ribes rotundifolium.
Ribes rubrum.
Passiflora incarnata.
Symphoricarpos racemosus.
Symphoricarpos vulgaris.
Catalpa bignonioides.
Maclura aurantiaca.
Populus grandidentata.
Poa annua.
Pinus Strobus.

It will be seen that the introduced plants amount to 15.5 per cent. of the total flora.

The several orders to which these belong, are shown in the Summary.

Shrubby Species.

Of the 342 "Forest Trees" enumerated in Sargent's preliminary catalogue of 1880, this flora embraces 85, or 24.8 per cent, of which 65 are large enough to have the dignity of timber trees. Of these 85, 25 are in the Polypetalous Division, but only 12 of this latter number are large; 9 are in the Monopetalous Division, all but 2 of which are large; 44 are in the Apetalous Division, 39 of which are large; and the remaining 7 are Coniferous, all full-sized trees.

The whole number of species which are shrubby or woody above ground is 194, which is 15.5 per cent of the whole; they are distributed as follows:

Polypetalous	83
Gamopetalous	36
Apetalous (Monochlamydeous)	64
Monocotyledonous (Endogenous)	4
Gymnospermous (Coniferous)	7
Total	194

For further particulars the reader can consult the Summary at the end of the catalogue.

Comparisons with Other Floras.

While these facts are of great interest in affording a clear conception of the character of our flora, they do not aid us in determining in what respects it is peculiar or marks a departure from | those of other portions of the country, or from that of the country at large. To institute comparisons with other local floras would of course carry me much too far for the general purpose of this paper, but it is both more interesting and more practicable to confront

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a few of the above results with similar ones, drawn from a consideration of a large part of the United States. For this purpose, as not only most convenient but as least liable to embrace facts calculated to vitiate the comparisons, I have chosen that portion of the United States situated east of the Mississippi river, and for the most part well covered by *Gray's Manual of Botany* for the Northern portion and *Chapman's Flora of the Southern States* for the Southern. The plants described in these works are conveniently collected into one series by the second edition of *Mann's Catalogue*, published under the supervision of the authorities at Cambridge, in 1872. Many changes have since been made in the names, &c., and a few new species added, but these are not sufficient to affect the general conclusions to be drawn from the following comparative tables.

Comparison of Species and Varieties.

The number of species and varieties of vascular plants enumerated in the work above referred to is 4,034, of which the 1,249 of the flora of Washington is 31 per cent. The comparison by groups, is as follows:

Groups.	Species and varieties in the		Per Cent.
	Eastern U. S.	Flora Columbiana.	
Polypetalæ	1,115	356	32
Gamopetalæ	1,314	389	30
Total Dichlamydeæ	2,429	745	31
Monochlamydeæ (Apetalæ)	349	124	36
Total Dicotyledons	2,778	869	31
Monocotyledons (Endogens)	1,034	331	32
Gymnospermæ	28	7	25
Total Phænogamia	3,840	1,207	31
Cryptogamia	194	42	22
Total vascular plants	4,034	1,249	31

93 | *Comparison of Genera.*

The whole number of genera in the flora of the Eastern United States is 1065. That of the Flora Columbiana, as already stated is 527. This is over 49 per cent, a much larger proportion than was shown by a comparison of the species. A comparison of the genera by groups, gives the following results:

Groups.	Genera represented in the		Per Cent.
	Eastern U. S.	Flora Columbiana.	
Polypetalæ	340	174	51
Gamopetalæ	379	169	45
Total Dichlamydeæ	719	343	48
Monochlamydeæ (Apetalæ)	97	47	48
Total Dicotyledons	816	390	48
Monocotyledons	198	112	57
Gymnospermæ	12	4	33
Total Phænogamia	1,026	506	49
Cryptogamia	39	21	54
Total vascular plants	1,065	527	49

The percentages here range from 33 in the Gymnosperms to 57 in the Monocotyledons, averaging between 49 and 50, whereas in the similar comparisons for species they ranged from 22 in the Cryptogams to 36 in the *Monochlamydeæ*. This result was to be expected since as the groups increase, the number represented in any local flora should be proportionally larger. For example, 116 orders out of the 156 are represented here, which is upwards of 74 per cent.

Comparison of Large Orders.

It will be interesting to compare in a manner similar to the foregoing, the number of species in several of the largest orders. For this purpose we may use the same orders mentioned a few pages back as the richest in species of any

belonging to this flora. The comparison may then be shown as follows:

Orders.	Eastern U. S.	Flora Col.	Per Cent.
1. Compositæ	497	149	30
2. Gramineæ	297	110	37
3. Cyperaceæ	357	108	30
4. Leguminosæ	208	57	27
5. Rosaceæ	104	46	44
6. Labiatæ	121	42	35
7. Cruciferæ	76	33	43
8. Scrophulariaceæ	97	32	33
9. Filices	134	30	22
10. Ranunculaceæ	80	27	34
11. Ericaceæ	89	26	29
12. Cupuliferæ	45	26	58
13. Orchidaceæ	71	24	34
14. Liliaceæ	82	24	29
15. Polygonaceæ	56	23	41
16. Umbelliferæ	63	22	35

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This table exhibits better perhaps than any other the special characteristics of the flora. The normal percentage being about 31, we see that in all but five of these sixteen largest orders our flora is in excess of that standard, while it is richest proportionally in the *Cupuliferæ*, *Rosaceæ*, and *Cruciferæ*, and poorest in the *Filices*, and *Leguminosæ*.

Comparison of Large Genera.

In like manner we may compare the fifteen large genera given in a preceding table.

Genera.	Eastern U. S.	Flora Col.	Per Cent.
1. Carex	180	70	39
2. Aster	63	21	33
3. Panicum	36	19	53
4. Solidago	61	18	30
5. Quercus	38	18	47
6. Polygonum	27	16	59
7. Desmodium	24	14	58
8. Salix	23	14	61
9. Juncus	38	14	37
10. Viola	24	13	54
11. Cyperus	41	12	29
12. Ranunculus	27	11	41
13. Eupatorium	24	11	46
14. Helianthus	27	10	37
15. Asclepias	22	10	45

95 | This table shows that in all the large genera except Solidago and Cyperus, the District of Columbia has more than its full proportion. The genus *Salix* is the one proportionally best represented, while *Polygonum*, *Desmodium*, *Panicum* and *Viola*, each exceed 50 per cent. *Quercus*, *Eupatorium* and *Asclepias* are also well filled out.

As already remarked, it would carry us too far to undertake the systematic comparison of our flora with those of other special localities, even were the data at hand. Few local catalogues are condensed and summarized for this purpose and the labor of doing this is very great. The recently published *Flora of Essex County Massachusetts*, prepared by Mr. John Robinson, however, forms something of an exception to this, and we may directly compare the larger classes and also the orders. The following tables will give an idea of the differences between that flora and our own:

Series, Classes, and Divisions.	Number of Orders.		Number of Genera.		Number of Species and Varieties.	
	Essex County.	Washington.	Essex County.	Washington.	Essex County.	Washington.
Polypetalæ	42	45	155	174	360	356
Gamopetalæ	25	27	158	169	358	389
Total Dichlamydeæ	67	72	313	343	718	745
Monochlamydeæ	18	19	44	47	132	124
Total Dicotyledons	85	91	357	390	850	869
Monocotyledons	17	20	120	112	392	331
Gymnospermæ (Coniferæ)	1	1	7	4	17	7
Total Phænogamia	103	112	484	506	1,259	1,207
Cryptogamia	5	4	20	21	65	42
Total vascular plants	108	116	504	527	1,324	1,249

96 | The sixteen large orders enumerated on page 89 may also be compared with profit:

Large Orders.	Number of Genera.		Number of Species and Varieties.	
	Essex County.	Washington.	Essex County.	Washington.
1. Compositæ	43	53	136	149
2. Gramineæ	50	43	128	110
3. Cyperaceæ	9	10	120	108
4. Leguminosæ	17	24	39	57
5. Rosaceæ	12	15	55	46
6. Labiatæ	22	23	35	42
7. Cruciferæ	14	16	29	33
8. Scrophulariaceæ	14	15	29	32
9. Filices	13	16	40	30
10. Ranunculaceæ	9	7	30	27
11. Ericaceæ	18	11	37	26
12. Cupuliferæ	6	7	16	26
13. Orchidaceæ	13	12	32	24
14. Liliaceæ	18	18	27	24
15. Polygonaceæ	3	3	27	23
16. Umbelliferæ	16	17	20	22

In the flora of Essex County, the orders *Umbelliferæ* (20) and *Cupuliferæ* (16) fall below the lowest of the sixteen for the flora of Washington, (*Umbelliferæ* 22), while on the other hand the *Caryophyllaceæ* (27), *Salicaceæ* (23), and *Naiadaceæ* (28), not in the list, rise above that number. These orders in the flora of Washington are represented respectively by 19, 19, and 9 species and varieties. With reference to the last named of these orders, however, it may be remarked that the genus *Potamogeton*, which constitutes the greater part of it, has been imperfectly studied here, and will certainly be largely increased when thoroughly known.

The orders in which this flora falls below that of Essex county are: the *Gramineæ*, *Cyperaceæ*, *Rosaceæ*, *Filices*, *Ranunculaceæ*, *Ericaceæ*, *Liliaceæ*, *Orchidaceæ*, and *Polygonaceæ*, nine in all. In the remaining seven orders there is a greater number of species here than there. It is noteworthy that our flora exceeds that of Essex county most in the *Compositæ*, *Leguminosæ*, and *Cupuliferæ*, and | next to these in the *Scrophulariaceæ*, *Labiatæ* and *Cruciferæ*. 97

Our comparatively poorest orders are the *Cyperaceæ*, *Rosaceæ*, *Ericaceæ* and *Filices*. Comparing in like manner the fifteen large genera enumerated on page 90 we are able to see still more definitely wherein the two floras differ.

Large Genera.	Number of Species and Varieties.	
	Essex County.	Washington.
1. Carex	71	70
2. Aster	25	21
3. Panicum	14	19
4. Solidago	19	18
5. Quercus	10	18
6. Polygonum	21	16
7. Desmodium	7	14
8. Salix	18	14
9. Juncus	14	14
10. Viola	11	13
11. Cyperus	11	12
12. Ranunculus	13	11
13. Eupatorium	7	11
14. Helianthus	5	10
15. Asclepias	7	10

The total number of species and varieties represented by these fifteen genera is thus considerably larger in the Washington flora (271), than in that of Essex county, (253); but whereas they are absolutely the largest genera here, this is not the case there. The genus *Potamogeton* numbers 23 in Mr. Robinson's Catalogue, and the genus *Scirpus* 14, while several others probably exceed ten. Those in the above list falling below ten, the lowest on the Washington list, are *Desmodium* (7), *Eupatorium* (7), *Asclepias* (7), and *Helianthus* (5). Those in which the Essex flora exceeds the Washington flora are *Carex*, *Aster*, *Solidago*, *Polygonum*, *Salix* and *Ranunculus*, though *Carex*, *Solidago* and *Cyperus* may be regarded as equal in the two floras, and *Juncus*

is exactly equal. In *Quercus*, *Desmodium*, *Eupatorium*, *Helianthus* and *Asclepias*, the Essex flora | is poor, only amounting in the second and fourth named, to half the number found here. 98

Relative to the above comparisons in general, it may be remarked first, that the flora of Essex county, Massachusetts, is much more thoroughly and exhaustively elaborated than that of the District of Columbia, lying as it does in the immediate center of botanical activity in this country. This alone is probably sufficient to account for all the difference in the number of species in the two localities, and it will probably be ultimately found that the two floras are very nearly equal. In the second place, if it should be thought that from its intermediate location between the southern and the northern sections of the country, our flora should naturally be the more rich in species, it may be satisfactorily urged on the other hand, that while we have only an inland territory, Essex county has both an inland and a maritime territory. Could our range be extended to embrace even a small extent of sea coast, the number would thereby be very largely increased.

As a final statistical exhibit, more comprehensive in its scope, and from a different point of view, I give below a table in which our local flora is compared not only with the floras above named, but with several others in America. As these several floras not only overlap to a considerable extent, but also differ widely in the total number of plants embraced by each, it is evident a numerical comparison would convey a very imperfect idea of the variety in their essential characteristics. It is therefore necessary to reduce them to a common standard of comparison, which has been done by disregarding the actual numbers and employing only the percentage which each group compared bears to the total for each respective flora. The relations of the several groups to the total vegetation of each flora is thus brought out, and a comparison of the percentages of the

same group in the different areas displays in the clearest manner possible the predominance or scantiness of the groups in each flora. Upon this must depend, in so far as botanical statistics can indicate it, the *facies* of each flora, its peculiarities and characteristics. As in previous comparisons, the table is restricted to Phenogamous and vascular Cryptogamous plants, and the same groups are employed, except that the large genera are omitted, while the number of orders is increased to the 23 largest of this flora, which is taken as the basis of comparison, and they are arranged in the order of rank with reference to it.

99 | The several floras compared with the total number of plants embraced in each, are as follows:

1.	Flora of Washington and vicinity	1,249
2.	Flora of Essex county, Massachusetts	1,324
3.	Flora of the State of Illinois	1,542
4.	Flora of Northeastern United States	2,365
5.	Flora of Southeastern United States	2,696
6.	Flora of Eastern United States (=4+5)	4,034
7.	Plants collected by the Fortieth Parallel Survey	1,254
8.	Plants collected by Lieut. Wheeler's Survey	1,535

For the flora of Illinois (No. 3), and also for that of the Northern United States, east of the Mississippi (No. 4), I have used, without verification, the figures of the *Catalogue of the Plants of Illinois*, 1876, prepared by Mr. Harry N. Patterson, as summarized in the preface. In the former case, the introduced species are included, but the varieties seem to be excluded. In the latter case, as stated by Mr. Patterson, the introduced species are excluded, as are also doubtless the varieties.

For the flora of the Southern United States, east of Mississippi (No. 5), which I have compiled from Dr. Chapman's *Flora of the Southern States*, indigenous species are alone taken, in order to make it conform as nearly as possible to the flora of the Northeastern United States (No. 4).

The plants collected by the Fortieth Parallel Survey (No. 7), and those collected on Lieut. Wheeler's Survey (No. 8), are introduced rather as a means of contrasting the Eastern with the Western portions of the continent, than as a proper part of the comparative botanical statistics of this vicinity. The former of these collections was very thoroughly and carefully made by an energetic and experienced botanist, Mr. Sereno Watson, and derives its chief value from this fact. It embraces, however, a territory having a somewhat special character from a botanical point of view, viz., in general terms, the Great Basin between the Rocky Mountains and the Sierra Nevada, and the High Plateaus and mountains immediately adjacent (Wasatch, Uintas, Sierras), with a restricted range north and south. The data are taken from the summary of the work prepared by Mr. Watson, and found on page XIV of the Report. The collections embraced in the Report of Lieut. Wheeler's Survey, on the other hand, were made by numerous collectors, some of them amateurs, and were scattered over a very wide extent of | western territory, including Colorado, New Mexico, Utah, Arizona and Nevada, and 100
continued through five years of exploration. They may be taken therefore to represent, with some correctness, the general character of our Western Flora, exclusive of the Pacific Coast. The facts given are derived from the "Table of Orders" on page 379. In both cases varieties are excluded.

For the remaining floras compared in the table (Nos. 1, 2, and 6), to avoid recompilation, the data previously used are repeated, species and varieties, including also introduced plants, being employed. As already intimated, however, this difference in the basis of compilation of different floras, applying as it does to the several groups and to the aggregate alike, cannot materially affect the percentages as computed.

The following is the Table of Percentages:

Groups.	Flora of Washington and Vicinity.	Flora of Essex County, Massachusetts.	Flora of the State of Illinois.	Flora of the Northeastern United States.	Flora of the Southeastern United States.	Flora of the total Eastern United States.	Plants collected by the 40th Parallel Survey.	Plants collected by Lieut. Wheeler's Survey.
Polypetalæ	28.5	27.2	28.5	26.8	28.9	27.6	35.1	31.9
Gamopetalæ	31.1	27.0	32.2	31.6	34.7	32.6	36.0	35.8
Total Dichlamydeæ	59.6	54.2	60.7	58.4	63.6	60.2	71.1	67.7
Monochlamydeæ	9.9	10.0	9.8	7.9	8.8	8.7	9.8	10.6
Total Dicotyledons	69.5	64.2	70.5	66.3	72.4	68.9	80.9	78.3
Monocotyledons	26.5	27.6	25.5	29.0	24.3	25.6	16.4	15.7
Gymnosperms	0.6	1.3	0.7	0.9	0.7	0.7	1.2	1.3
Total Phænogamia	96.6	95.1	96.7	96.2	97.4	95.2	98.5	95.3
Cryptogamia	3.4	4.9	3.3	3.8	2.6	4.8	1.5	4.7
Total vascular plants	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0

Orders.	Flora of Washington and Vicinity.	Flora of Essex County, Massachusetts.	Flora of the State of Illinois.	Flora of the Northern United States.	Flora of the Southern United States.	Flora of the total Eastern United States.	Plants collected by the 40th Parallel Survey.	Plants collected by Lieut. Wheeler's Survey.
1. Compositæ	11.9	10.3	13.0	12.2	13.7	12.3	16.5	16.6
2. Gramineæ	8.9	9.7	7.8	7.5	7.2	7.4	5.4	7.8
3. Cyperaceæ	8.6	9.1	8.5	10.5	8.0	8.9	4.4	3.8
4. Leguminosæ	4.6	2.9	4.7	4.3	6.1	5.2	7.2	8.2
5. Rosaceæ	3.7	4.2	3.2	3.0	2.2	2.6	3.4	2.9
6. Labiatæ	3.4	2.6	2.8	2.2	2.8	3.0	0.9	2.2
7. Cruciferæ	2.6	2.2	2.1	2.0	1.4	1.9	4.4	2.8
8. Scrophulariaceæ	2.6	2.2	2.7	2.3	2.5	2.4	4.5	4.8
9. Filices	2.4	3.0	2.3	2.4	2.1	3.3	1.0	4.3
10. Ranunculaceæ	2.2	2.3	2.7	2.3	1.9	2.0	3.0	2.3
11. Ericaceæ	2.1	2.8	0.9	2.9	2.0	2.2	1.3	0.9
12. Cupuliferæ*	2.1	1.8	1.4	1.5	1.3	1.4	0.4	0.9
13. Liliaceæ	1.9	2.0	2.1	2.4	2.1	2.0	3.0	1.5
14. Orchidaceæ	1.9	2.4	1.8	2.4	1.9	1.7	0.6	0.5
15. Polygonaceæ	1.8	2.0	1.9	1.1	1.5	1.4	4.0	3.2
16. Umbelliferæ	1.8	1.5	1.8	1.7	1.6	1.6	2.4	1.2
17. Caryophyllaceæ	1.5	2.0	1.4	1.5	1.5	1.5	2.2	1.6
18. Salicaceæ	1.5	1.7	1.2	0.8	0.3	0.7	0.9	0.8
19. Onagraceæ	0.9	1.1	1.2	1.2	1.3	1.1	2.3	2.4
20. Saxifragaceæ	0.7	1.0	0.8	1.5	0.9	1.1	2.1	1.4
21. Chenopodiaceæ	0.7	1.3	0.7	0.5	0.5	0.6	2.1	1.5
22. Naiadaceæ	0.7	2.1	1.2	1.2	0.4	1.0	0.7	0.3
23. Polemoniaceæ	0.5	0.1	0.5	0.3	0.5	0.4	3.3	1.8

*Including the Betulaceæ.

Comparisons have already been made of our local flora with that of Essex county, Massachusetts, which contains so nearly the same number of plants. In examining the percentages in the above table, these distinctions are equally manifest. In both divisions of the *Dichlamydeæ*, and also in the Dicotyledons, and the total *Phænogamia*, our flora is richer than that of Essex county, while in the *Monochlamydeæ*, the Monocotyledons, the Gymnosperms, and the Cryptogams, it falls below. In the *Compositæ*, *Leguminosæ*, *Labiatæ*, *Cruciferæ*, *Scrophulariaceæ*, *Cupuliferæ*, and a few other orders it is in excess, while in the *Gramineæ*, *Cyperaceæ*, *Rosaceæ*, *Filices*, *&c.*, the Essex flora leads.

In the comparison with the flora of the State of Illinois, one is struck by the marked similarity in the position of the groups, not|withstanding the well known differences in the actual species. In the *Gamopetalæ*, and total 102
Dichlamydeæ, as also in the *Monochlamydeæ* the difference is very slight, while in the *Polypetalæ* it disappears entirely. The Dicotyledons are therefore nearly the same, and we find this true also of the Monocotyledons, and the Gymnosperms. Whatever slight variations occur in the above named groups, they are so adjusted as nearly to balance each other, so that when we reach the total *Phænogamia*, we again have substantial unison, which of course is maintained in the *Cryptogamia*.

This harmony is less pronounced in the larger orders, the *Compositæ* being richer, and the *Gramineæ* poorer there than here. In the *Cyperaceæ*, *Leguminosæ*, *Scrophulariaceæ*, and *Filices*, the difference is not great, but in the *Rosaceæ*, *Labiatæ*, *Cruciferæ*, and *Cupuliferæ*, the Washington flora is decidedly in advance, and in the *Ericaceæ* it is of course in very marked contrast. In the *Orchidaceæ*, *Polygonaceæ*, *Umbelliferæ*, *Caryophyllaceæ*, and *Polemoniaceæ*, there is substantial, or exact identity. In the *Ranunculaceæ*, *Onagraceæ*, *Naiadaceæ*, and *Liliaceæ*, besides the *Compositæ* already mentioned, the Illinois flora leads that of Washington. On the whole there is a remarkable similarity in the

facies of these two floras, which may be due to their inland situation, with fluviatile areas, and similar position as to latitude. Considering, however, the marked specific peculiarities of the flora of the flat prairies of the West, we would have naturally looked for a corresponding distinctness in the larger groups and orders.

The comparisons of our flora, from this point of view, with those of the Northern and Southern States, east of the Mississippi river, and with these two combined, as represented in the next three columns, proves of the highest interest, and will repay somewhat close inspection. It has often been asked, to what extent the flora of Washington is affected by influences of a peculiarly southern character, and while it has generally been conceded that it belongs clearly to the northern section of the country, many facts, such as those previously set forth, relative to autumnal flowering and early flowering, as well as to the number of species, which exhibit more or less green foliage throughout the winter, combine to give it a decidedly southern aspect. In so far as the method of testing such questions which has been here adopted can be relied upon, this southern leaning on the part of the Washington flora is clearly exhibited in this table.

103 In letting the eye follow columns four and | five, the differences are well marked in nearly all the groups, and in most of the large orders. These are what express statistically the essential characteristics of the northern as contrasted with the southern flora. It is also obvious that the figures in column six will, in most cases, express the mean between these two extremes. To obtain the true position of our flora, it is necessary to observe toward which of these extremes it most nearly approaches, and whether it falls on the northern or southern side of the mean established by column six. In instituting this comparison, we perceive at the outset, that in the Polypetalous division, it falls so far on the southern side as to come within four tenths of one per cent of being identical with the flora of the Southern States. In the *Gamopetalæ*, however, it agrees quite

closely with the flora of Northern States, so that in the *Dichlamydeæ* as a whole, it coincides very well with the mean for both sections. The *Monochlamydeæ* agree better with those of the Southern States and the total Dicotyledons fall largely on the southern side of the mean. The Monocotyledons also fall somewhat on the southern side, while the Gymnosperms are below the mean which here corresponds with the southern flora. This leaves the total Phænogams, occupying an intermediate position. The Cryptogams are also very nearly intermediate, though approaching the northern side.

Considering next the relations of the large orders, we find that in the *Compositæ* our flora is northern in aspect. In the *Gramineæ* it is very exceptionally rich, surpassing all the larger areas and approaching that of Essex county, Massachusetts. In the *Cyperaceæ*, which are peculiarly typical for the purpose, on account of being indigenous in all the floras, it does not correspond at all, either with the northern section or with the average of both sections, but does agree very closely with the exceptionally meager representation of the southern flora. The *Leguminosæ* are here northern in aspect, the *Rosaceæ*, like the *Gramineæ*, exceptionally rich, far exceeding either section, as is also the case with the *Labiatæ* and the *Cruciferæ*. The ferns are northern in their degree of representation, as are the *Ranunculaceæ* while the *Ericaceæ* and *Scrophulariaceæ* are southern. The *Cupuliferæ* again are anomalous and tower above all other floras. The *Liliaceæ* are southern, as are also the *Orchidaceæ*. The *Polygonaceæ* are in excess, and in so far southern in aspect, while the *Umbelliferæ*, also in excess, denote a northern inclination. The *Caryophyllaceæ* are remarkable for | showing the same percentage in all of the four floras now 104
under comparison. The *Salicaceæ* are largely in excess of every flora compared in the table, except that of Essex county, Massachusetts, while the *Onagraceæ* and *Saxifragaceæ* both fall below the normal, the latter, however, showing a southern tendency. The *Naiadaceæ* are southern,

as are also the *Polemoniaceæ*, while the *Chenopodiaceæ* are slightly in excess in their degree of representation.

Now, as this locality has been classed as northern, we should not expect to find it occupying an intermediate position, which would place it on the boundary line between the northern and the southern flora, but we should expect to find it agreeing closely with the northern flora, or at least lying midway statistically, as it does geographically, between the dividing line or medium, represented by the total eastern flora and the northern flora. So far is this from being the case, however, that we actually find it occupying a position considerably below the medium line, and between this and the line of the southern flora; a position which would be geographically represented by the latitude of Nashville or Raleigh, or even by Memphis or Chattanooga.

This result is very remarkable, and while the proofs from statistics are, perhaps, not alone to be relied upon, it serves to confirm many facts recorded which have puzzled the observers of the phenomena of the vegetable kingdom in this locality.

The results of the careful comparison of the two remaining columns need not be here summed up, as the reader will readily perceive their general import, and he will not be likely to stop with considering the relations of the local flora with those of the far West, but will probably seek for more general laws governing the vegetation of the eastern and western sections, as we have already done to some extent for the northern and southern sections.

Abundant Species.

It was Humboldt who remarked that of the three great Kingdoms of Nature, the Mineral, the Vegetable, and the Animal, it is the Vegetable which contributes most to give character to a landscape. This is very true, and it is also true, that botanists rarely take account of this fact. The latter are always interested in the relative numbers of species

belonging to different Classes, Families, and Genera, rather than in the mere superficial aspects of the vege|ta- 105
tion. It is, however, not the number of species, but individuals which give any particular flora its distinguishing characteristics to all but systematic botanists, and it is upon this, that in the main depends the commercial and industrial value of the plant-life of every region of the globe. It is often the omnipresence of a few, or even of a single, abundant species that stamps its peculiar character upon the landscape of a locality. This is to a far greater extent true of many other regions, especially in the far West, than it is of this; the vegetation of the rural surroundings of Washington being of a highly varied character, as much so perhaps as that of any part of the United States. And yet there are a comparatively few species, which from their abundance chiefly lend character to the landscape, and really constitute the great bulk of the vegetation. The most prominent, if not actually the most numerous of these, are of course, certain trees and notably several species of oak. Probably the most abundant tree here, as in nearly all parts of the country, is *Quercus alba*, the white oak; but *Q. Prinus*, the chestnut oak, *Q. coccinea*, the scarlet oak, *Q. palustris*, the swamp oak, and *Q. falcata*, the Spanish oak, are exceedingly common. The most abundant hickory is *Carya tomentosa*, the mockernut. *Liriodendron Tulipifera*, the tulip-tree, often improperly called white poplar, besides being one of the commonest trees, is the true monarch of our forests, often attaining immense size. It is a truly beautiful tree whose ample foliage well warrants the recent apparently successful experiments in introducing it as a shade tree for the streets of the city. Among other common trees may be mentioned the chestnut (*Castanea vulgaris, Lam., var. Americana*, A.DC.), the beech (*Fagus ferruginea*), the red maple (*Acer rubrum*), the sycamore (*Platanus occidentalis*), the red or river birch (*Betula nigra*), the white elm (*Ulmus Americana*), the sour gum (*Nyssa multiflora*), the sweet gum (*Liquidamber Styraciflua*), the scrub pine (*Pinus*

inops), the pitch pine (*P. rigida*), and the yellow pine (*P. mitis*).

Of the smaller trees, *Cornus florida*, the flowering dogwood, and *cercis Canadensis*, the red-bud or Judas tree are very abundant, and chiefly conspicuous in the spring from the profusion of their showy blossoms; all three species of sumac are common. *Hamamelis Virginica*, the witch-hazel, and *Viburnum prunifolium*, the black haw, abound;
106 *Sassafras officinale*, sassafras, *Castanea pumila*, | the chinquapin, and *Juniperus Virginiana*, the red cedar, also belong to this class.

Of the smaller shrubby vegetation, we may safely claim as abundant *Cornus sericea*, and *C. alternifolia*, the silky, and the alternate-leaved cornel, *Viburnum acerifolium*, *V. dentatum*, and *V. nudum*, arrow-woods, *Gaylussacia resinosa*, the high-bush huckleberry, *Vaccinium stamineum*, the deer berry, *V. vacillans* and *V. corymbosum* the blueberries, *Leucothoë racemosa*, *Andromeda Mariana*, the stagger bush, *Kalmia latifolia*, the American laurel, or calico-bush, *Rhododendron nudiflorum*, the purple azalea, *Lindera Benzoin*, the spice bush.

Of vines besides three species of grape which are abundant, we have *Ampelopsis Virginiana*, the Virginia creeper, or American woodbine, *Rhus Toxicodendron*, the poison ivy, and *Tecoma radicans*, the trumpet vine, which give great beauty and variety to the scenery.

The most richly represented herbaceous species may be enumerated somewhat in their systematic order. Of *Polypetalæ*, may be mentioned *Ranunculus repens*, *Cimicifuga racemosa*, *Dentaria laciniata*, *Viola cucullata*, *Viola pedata*, *var. bicolor*, and *V. tricolor*, *var. arvensis; Stellaria pubera*, *Cerastium oblongifolium*, *Geranium maculatum*, *Impatiens pallida*, and *I. fulva; Desmodium nudiflorum*, *D. acuminatum*, and *D. Dillenii; Vicia Caroliniana*, *Potentilla Canadensis*, *Geum album*, *Saxifraga Virginiensis*, *Œnothera fruticosa*, and *Thaspium barbinode*. In the *Gamopetalæ* before *Compositæ*, we have *Galium Aparine*, *Mitchella repens*,

Houstonia purpurea, and *H. cærulea*. In the *Compositæ*, the most conspicuous are: *Vernonia Noveboracense*, *Eupatorium purpureum*, *Liatris graminifolia*, *Aster patens*, *A. ericoides*, *A. simplex*, and *A. miser*; *Solidago nemoralis*, *S. Canadensis*, *S. altissima*, and *S. ulmifolia*; *Chrysopsis Mariana*, *Ambrosia trifida*, and *A. artemisiæfolia*, (these behaving like introduced weeds); *Helianthus divaricatus*, *Actinomeris squarrosa*, *Rudbeckia laciniata*, and *R. fulgida*; *Coreopsis verticillata*, *Bidens cernua*, *Verbesina Siegesbeckia*, *Gnaphalium polycephalum*, *Antennaria plantaginifolia*, *Hieracium venosum*, and *H. Gronovii*; *Nabalus albus*, and *N. Fraseri*; *Lactuca Canadensis*.

The remaining *Gamopetalæ* furnish as abundant species: *Lobelia spicata*, *Chimaphila umbellata*, and *C. maculata*; *Veronica officinalis*, and *V. Virginica*; *Gerardia flava*, *Verbena hastata*, and *V. urticæfolia*; *Pycnanthemum incanum*, and *P. linifolium*; *Collinsonia Canadensis*, | *Salvia* 107
lyrata, *Monarda fistulosa*, and *M. punctata*; *Nepeta Glechoma*, *Brunella vulgaris*, *Mertensia Virginica*, *Phlox paniculata*, and *P. divaricata*; *Solanum Carolinense*, and *Asclepias Cornuti*.

Of herbaceous *Monochlamydeæ* may be named *Polygonum Virginianum*, *P. sagittatum*, and *P. dumetorum*; *Laportea Canadensis*, *Pilea pumila*, and *Bœhmeria cylindrica*.

The Monocotyledons give us *Arisæma triphyllum*, the Indian turnip, *Sagittaria variabilis*, *Aplectrum hyemale*, *Erythronium Americanum*, *Luzula campestris*, *Juncus effusus*, *Juncus marginatus*, and *Juncus tenuis*; *Pontederia cordata*.

Of the *Cyperi*, *C. phymatodes*, *C. strigosus* and *C. ovularis* are the most common. *Eleocharis obtusa* and *E. palustris*; *Scirpus pungens*, *S. atrovirens*, *S. polyphyllus*, and *S. Eriophorum*, are very conspicuous. Of *Carices*, *C. crinita*, *C. intumescens*, the various forms of *C. laxiflora*, *C. platyphylla*, *C. rosea*, *C. scoparia*, *C. squarrosa*, *C. straminea*, *C. stricta*, *C. tentaculata*, *C. virescens* and *C. vulpinoides*, are the most obtrusive. In the *Gramineæ*, those which most uniformly strike the eye are *Agrostis scabra*, *Muhlenbergia Mexicana*,

and *M. sylvatica; Tricuspis seslerioides, Eatonia Pennsylvanica, Poa pratensis, Poa sylvestris,* and *P. brevifolia; Eragrostis pectinacea, Festuca nutans, Bromus ciliatus, Elymus Virginicus, Danthonia spicata, Anthoxanthum odoratum, Panicum virgatum, P. latifolium, P. dichotomum,* (with a multitude of forms), and *P. depauperatum; Andropogon Virginicus,* and *A. scoparius.*

Of ferns *Polypodium vulgare, Pteris aquilina, Adiantum pedatum, Asplenium ebeneum,* and *A. Filix-fœmina; Phegopteris hexagonoptera, Aspidium acrostichoides, A. marginale,* and *A. Noveboracense; Osmunda regalis, O. Claytoniana,* and *O. cinnamomea,* are the most constantly met with.

Lycopodium lucidulum is quite common, and *L. complanatum* is very abundant in certain localities.

Besides the above, which are all indigenous to our flora, there are many introduced species in the vicinity of the city, and of cultivation everywhere which manifest, here as elsewhere, their characteristic tendency to crowd out other plants and monopolize the soil.

Such are the most general features which the traveler, accustomed to observe the vegetable characteristics of localities visited, may expect to see when he pays his re-
108 spects to the Potomac valley. To | some even this imperfect description might furnish a fair idea of our vegetable scenery without actually seeing it.

Classification Adopted.

In endeavoring to conform to the latest authoritative decisions relative to the most natural system of classification, I have followed, with one exception, the arrangement of the *Genera Plantarum* of Bentham and Hooker so far as this goes, and the accepted authorities of Europe and America for the remainder. For the *Gamopetalæ* after *Compositæ,* however, covered by Prof. Gray's *Synoptical Flora of North America,* I have followed that work, which is

substantially in harmony with the *Genera Plantarum*. In the arrangement of the orders, too, for the *Polypetalæ*, Mr. Sereno Watson's *Botanical Index* has in all cases been conformed to, as also not materially deviating from the order adopted by Bentham and Hooker. In the genera there are numerous discrepancies between the works last named, and in the majority of these cases the American authorities have been followed. For example, Bentham and Hooker have thrown *Dentaria* into *Cardamine*, *Elodes* into *Hypericum*, and *Ampelopsis* into *Vitis*, and *Pastinaca* and *Archemora* into *Peucedanum*. The change of *Spergularia* to *Lepigonum* is adopted, as well as a few alterations in orthography where the etymology seemed to demand them, as Pyrus to Pirus and Zanthoxylum to Xanthoxylum. I have also declined to follow Bentham and Hooker in the changes which they have made in the terminations of many ordinal names. The termination *aceæ* is doubtless quite arbitrary in many cases, and perhaps, cannot be defended on etymological grounds, but as a strictly ordinal ending it has done good service in placing botanical nomenclature on a more scientific footing. It is also true that the old system does not always employ it, as in some of the largest orders, *e. g.*, *Cruciferæ*, *Leguminosæ*, *Compositæ*, *Labiatæ;* but whatever changes are made should rather be in the direction of making it universal than less general. Bentham and Hooker do not adopt a universal termination, neither do they abolish the prevailing one, and they retain it in the majority of cases; but in certain cases, for which they doubtless have special reasons, they substitute a different one, and one which is often far less euphonious. The following are the orders represented in this catalogue in which the ter|mination *aceæ* is retained by American and altered by English authorities. 109

American.	*English.*
Berberidaceæ.	Berberideæ.
Cistaceæ.	Cistineæ.
Violaceæ.	Violarieæ.

American.	*English.*
Polygalaceæ.	Polygaleæ.
Caryophyllaceæ.	Caryophylleæ.
Portulacaceæ.	Portulaceæ.
Hypericaceæ.	Hypericineæ.
Celastraceæ.	Celastrineæ.
Vitaceæ.	Ampelideæ.
Saxifragaceæ.	Saxifrageæ.
Hamamelaceæ.	Hamamelideæ.
Lythraceæ.	Lythrarieæ.
Onagraceæ.	Onagrarieæ.
Passifloraceæ.	Passifloreæ.
Cactaceæ.	Cacteæ.
Valerianaceæ.	Valerianeæ.
Asclepiadaceæ.	Asclepiadeæ.
Gentianaceæ.	Gentianeæ.
Borraginaceæ.	Borragineæ.
Scrophulariaceæ.	Scrophularineæ.
Lentibulaceæ.	Lentibularieæ.
Plantaginaceæ.	Plantagineæ.
Nyctaginaceæ.	Nyctagineæ.
Lauraceæ.	Laurineæ.
Juglandaceæ.	Juglandeæ.
Salicaceæ.	Salicineæ.
Ceratophyllaceæ.	Ceratophylleæ.

On the other hand, the British authorities are followed in uniting the *Saururaceæ* with the *Piperaceæ*, and also in placing the *Paronychieæ*, reduced to a sub-order under the *Illecebraceæ;* but from the certain relationship of this order with the *Caryophyllaceæ*, it is deemed unnatural to separate these two orders by putting the former into the Monochlamydeous division. [See *American Naturalist*, November, 1878, p. 726.] On the same ground of apparently close relationship, I have followed Bentham and Hooker in abolishing the *Callitrichaceæ*, and placing *Callitriche* in the *Haloragеæ*. On the other hand I have followed Gray in retaining the *Lobeliaceæ*, as also in keeping the *Ericaceæ* intact, and not slicing off the *Vacciniaceæ* from one end, and the *Monotropeæ* from the other, as is done in the *Genera Plantarum*.

| In the *Gamopetalæ*, before and including *Compositæ*, in the *Monochlamydeæ*, and throughout the Monocotyledons, serious difficulties occur in consequence of a want of recent systematic works from the American point of view. In nearly all cases the names as well as the arrangement of Gray's *Manual*, 5th edition, have here been adopted. I have, however, been able to avail myself of a number of recent revisions of genera made by Gray, Watson, and Engelmann,* and published in various forms, chiefly in the Proceedings of the American Academy of Arts and Sciences. I have also derived many useful hints from the *Flora of California*, from the botanical reports of the various Western Surveys, from Sargent's Catalogue of the Forest Trees of North America, and from the Flora of Essex county, Massachusetts. 110

Mr. M. S. Bebb, of Rockford, Illinois, has shown great kindness not only in determining all the uncertain *Salices*, but in generously drawing up a list of them in the order of their nearest natural relationship, which is followed implicitly in the catalogue.

For the Ferns, the magnificent work of Prof. Eaton has furnished everything that could be desired, and is unswervingly adhered to.

The following genera in the *Compositæ* have been changed by Bentham and Hooker, but the new names cannot be adopted until the species have been worked up by American botanists. The old ones are therefore retained with a simple indication of the recent disposition.

*While I have gladly adopted the arrangement of the species of *Quercus* decided upon by Dr. Engelmann after so careful a study, I cannot do so without recording a gentle protest against the position to which he assigns *Q. palustris*, viz., between *Q. falcata*, and *Q. nigra*, and far removed from *Q. rubra*. Not only the shallow, finely-scaled cup, but especially its light-colored buds and thin early leaves, as also a special *facies* belonging to its aments and foliage, ally this species with *Q. rubra*, and distinguish these two species as a group from all others found in this flora.

Maruta has been made Anthemis.
Leucanthemum has been made Chrysanthemum.
Cacalia has been made Senecio.
Lappa has been made Arctium.
Cynthia has been made Krigia.
Mulgedium has been made Lactuca.
Nabalus has been made Prenanthes.

111 | Several of these cases are a return to the older names, and whether they will be adopted by American authorities it is impossible to say.

It remains to consider the one deviation above referred to from the prevailing system of botanical classification, which it has been thought proper to make in the subjoined list of plants. This consists in placing the *Gymnosperms*, here represented only by the single order *Coniferæ*, after the Monocotyledons and next to the Cryptogams.

It is not the proper place here to state the already well known grounds upon which this position of the Gymnosperms has been defended. [See *American Naturalist*, June, 1878, pp. 359 to 378.] It is sufficient to point out that the correctness of this arrangement was recognized by Adrien de Jussieu, and has been repeatedly maintained by later botanists of eminence. The object in adopting it here, however, is not simply because it seems fully justified by the present known characters of plants, for consistently to do this would also require that the *Polypetalæ* be placed before the *Monochlamydeæ* (in the descending series), and that numerous other changes be made. So wide a departure from the existing system would seriously detract from the convenience of the work as a practical aid to the local botanist, and aside from the labyrinth of nice and critical points into which it must inevitably lead, it would not be advisable in the present state of botanical literature. But as the position of the Gymnosperms is the most glaringly inconsistent of all the defects of the present so-called Natural System, and as the *Coniferæ* are represented here by only

four genera and seven species, it is evident that no serious objection could arise on the ground of inconvenience, while at the same time it may serve some useful purpose in directing the minds of botanists who may look over the work to the obvious rationality of this classification, and contribute its mite towards awakening them to the recognition of a truth which, I cannot doubt, must sooner or later find expression in all accepted versions of the true order of nature with respect to the vegetable kingdom.

Common Names.

I am well aware that in recent times it has become more and more the practice among botanists to eschew all common or popular names of plants. This sentiment I share to a great extent and will | therefore remark at the outset
112 that the best common name for a plant is always its systematic name, and this should be made a substitute for other popular names wherever and whenever it can be done. In most cases the names of the genera can be employed with entire convenience and safety; and in many cases they are to be defended on the ground of euphony. How much better, for example, the name *Brunella* sounds than either Self-heal, or Heal-all, both of which latter, so far as their meaning goes, express an utter falsehood. Some works professing to give common names frequently repeat the generic name as such. This has seemed to me both unnecessary and calculated to mislead. It is not done where other accepted common names exist, and thus the implication is that in such cases it is incorrect to use the Latin name. Again it is only done for the commoner species, leaving it to be inferred that there is no popular way of designating the rarer ones. The plan here followed is to regard the genus as the best name to use in all cases, and as *ex officio* the proper common name of every plant, and, therefore, not in need of being repeated in different type as such in any case. But in addition it has been deemed best to give such appro-

priate or well established common names as can be found. Some scientific men seem disposed to forget that it is the things rather than the names that constitute the objects of scientific study. There is a vast amount of true scientific observation made by mere school-girls and rustics, who do not know the name of the branch of science they are pursuing. A knowledge of a plant by whatever name or by no name at all is scientific knowledge, and the devotees of science should care less for the means than the end which they have in view. Individuals differ in their constitution and character. The sound or sight of a Latin word is sometimes sufficient, in consequence of ineradicable, constitutional or acquired idiosyncrasies, to repel a promising young man or woman from the pursuit of a science for which genuine aptitude and fondness exist. For such and other classes, common English names have a true scientific value. The object should be to inspire a love for plants in all who can be made to take an interest in them, and to this end to render the science of Botany attractive by every legitimate means available. In so far, therefore, as English names of plants can be made conducive to this end, they should be employed. Their inadequacy to the true needs of the science
113 in its later stages | cannot fail to impress itself upon all who pursue it to any considerable extent.

Finally, common names are not wholly without their scientific uses. A few of them have proved more persistent than any of the systematic names, as I have had occasion to observe in examining the *Prodromus Floræ Columbianæ* of 1830, in which difficult work, I must confess, they frequently rendered me efficient aid in determining the identity of plants, which the Latin names used did not reveal.

In appending common names to the plants of this vicinity *The Native Flowers and Ferns of the United States*, by Prof. Thomas Meehan, has been followed in most cases, so far as this work goes, but this of course embraces but a fraction of the entire flora. Most of the remaining names are taken

from Gray's *Manual* of Botany, and from his *Synoptical Flora of North America*. In many cases some of the names given which do not seem appropriate are omitted, and in a few cases those given have been slightly changed. A small number of local names given, not found in any book, but in themselves very expressive, have been given, as "curly head" for *Clematis ochroleuca*, &c.; and in a few other cases, names have been assigned to abundant species on the analogy of those given for allied genera or species.

Concluding Remarks.

The foregoing remarks on the value of common names naturally suggest a few general reflections with which our introduction will conclude.

The popularization of science is now a leading theme of scientific men. To accomplish this, certain branches of science must first become a part of liberal culture. The pursuit of fashion, which is usually regarded as productive solely of evil, may be made an agency of good. If it could become as much of a disgrace to be found ignorant of the flora or fauna of one's native place as it now is to be found ignorant of the rules of etiquette or the contents of the last new novel, devotees of Botany and natural history would immediately become legion, and the woods and fields would be incessantly scoured for specimens and objects of scientific interest. It should be the acknowledged work of educationalists to make science fashionable and call to their aid these powerful social sentiments in demanding the recognition of its legitimate claims.

|Of all the natural sciences, that of Botany is the most easily converted into a branch of culture. Its 114
objects appeal directly to the highest esthetic faculties. It naturally allies itself with the arts of drawing, painting, and sketching, and the deeper the insight into its mysteries the stronger does it appeal to the imagination. Its pursuit, besides being the best possible restorer of lost, and preserver

of good health, is a perpetual source of the purest and liveliest pleasure. The companionship of plants, which those who do not know them cannot have, is scarcely second to that of human friends. The botanist is never alone. Wherever he goes he is surrounded by these interesting companions. A source of pure delight even where they are familiarly known to him, unlike those of his own kind, they grow in interest as their acquaintance grows less intimate, and in all his travels they multiply immensely his resources of enjoyment.

The man of science wonders what the unscientific can find to render travel a pleasure, and it must be confessed that a great many tourists of both sexes go at the behest of fashion, and care little more for nature when crossing the Alps than did Julius Cæsar, who could only complain of the bad roads and while away the hours in writing his grammatical treatise, *De Analogia*. While all forms of natural science, so far from paralyzing the esthetic faculties, tend powerfully to quicken them, that of Natural History, and especially of Botany, awakens such an interest in Nature and her beautiful objects, that those who have once tasted pleasure of this class may well consider other pleasures insipid.

But notwithstanding these attractions which Botany possesses above other sciences, there exists among a small class of scientific men a disposition to look down upon it as lacking scientific dignity, as mere pastime for school-girls or fanatical specialists. This feeling is most obvious among zoölogists, some of whom affect to disdain the more humble forms of life and the simplicity of the tame and stationary plant.

This sentiment, though now happily rare, is natural and really constitutes what there is left of that proud spirit with which man has ever approached the problems of Nature. His first studies disdained even so complicated an organism as man himself, and spent themselves in the pursuit of spiritual entities wholly beyond the sphere of science.

Later he deigned to study *mind* detached from body and from matter, still later he attacked some of the higher manifestations of *life*. Ethics came next, and social organization; then anthropological questions were opened, and next those of physiology and anatomy, and at last of comparative anatomy and structural zoölogy. Phytology brought up the rear and was long confined to the most superficial aspects. It is only in recent times that plants and all the other lowly organisms have begun to receive proper attention, and only since this has been done has there been made any real progress in solving the problems of Biology. 115

It is a paradox in science that its most complicated forms must first be studied and its simplest forms last, while only through an acquaintance with the latter can a fundamental knowledge of the former be obtained. The history of biological science furnishes many striking illustrations of this truth, the most interesting of which is perhaps to be found in the labors of the two great French savants, Cuvier and Lamarck. The former spent his life and powers in the study of vertebrate zoölogy amid the most complex living organisms. The latter devoted his energies to Botany and to Invertebrate Zoölogy, including the protozoan and protistan kingdoms. The former founded his great theory of types, and his cosmology of successive annihilations and reconstructions of the life of the globe. The latter promulgated his theory of unbroken descent with modification. The conclusions of the former were accepted in his day, and are rejected in ours, those of the latter were rejected in his own lifetime, but now form the very warp of scientific opinion.

Let no botanist, therefore, or person contemplating the study of Botany, be deterred by the humble nature of the objects he would cultivate. The humblest flower or coarsest weed may contain lessons of wisdom more profound than can be drawn from the most complicated conditions of life or of mind.

The city of Washington is becoming more and more a center, not only of scientific learning and research, but also of art and every form of liberal culture. Already the public schools have reached out and taken Botany into their curriculum, and we have seen that as a field for the pursuit of this branch of science the environs of the National Capital are in a high degree adapted. Science and culture must go hand in hand. Culture must become more scientific, and science more cultured. Botany has an important part to perform in this work of reconciliation, and there is no good reason why Washington may not become one of the foci
116 from | which these influences are to radiate. It has been such reflections as these, aside from the practical needs for such a work, that have encouraged me to persevere in this humble, indeed, but not the less laborious task, and if it shall be found useful, to however slight a degree, in promoting these worthy objects, no regrets will arise at having undertaken it.

SUMMARY.

No.	ORDERS.	Genera.	Species.	Varieties.	Species and Varieties.	Introduced Plants.	Woody Plants.	Trees.
1	Ranunculaceæ	7	23	4	27	3	..	..
2	Magnoliaceæ	2	2	..	2	..	2	2
3	Anonaceæ	1	1	..	1	..	1	1
4	Menispermaceæ	1	1	..	1	..	1	..
5	Berberidaceæ	4	4	..	4	1	1	..
6	Nymphæaceæ	3	3	..	3	..	..	..
7	Sarraceniaceæ	1	1	..	1	..	..	..
8	Papaveraceæ	3	3	..	3	2	..	..
9	Fumariaceæ	3	3	..	3	1	..	..
10	Cruciferæ	16	32	1	33	15	..	..
11	Cistaceæ	2	2	..	2	..	..	..
12	Violaceæ	2	9	5	14	..	..	..
13	Polygalaceæ	1	7	..	7	..	..	..
14	Caryophyllaceæ	9	19	..	19	8	..	..
15	Illecebraceæ	2	2	1	3	..	..	..
16	Portulacaceæ	2	2	..	2	1	..	..
17	Hypericaceæ	3	9	..	9	1	1	..
18	Malvaceæ	4	7	..	7	5	..	..
19	Tiliaceæ	1	1	..	1	..	1	1
20	Linaceæ	1	3	..	3	1	..	..
21	Geraniaceæ	4	9	..	9	3	..	..
22	Rutaceaæ	2	2	..	2	1	2	..
23	Ilicineæ	1	4	..	4	..	4	1
24	Celastraceæ	2	3	1	4	..	4	..
25	Rhamnaceæ	1	2	..	2	..	2	..

No.	ORDERS.	Genera.	Species.	Varieties.	Species and Varieties.	Introduced Plants.	Woody Plants.	Trees.
26	Vitaceæ	2	6	..	6	..	6	..
27	Sapindaceæ	3	5	..	5	..	5	4
28	Anacardiaceæ	1	6	..	6	..	6	1
29	Leguminosæ	24	55	2	57	13	4	3
30	Rosaceæ	15	43	3	46	12	30	8
31	Saxifragaceæ	8	9	..	9	3	5	..
32	Crassulaceæ	2	3	..	3	..	..	..
33	Droseraceæ	1	1	..	1	..	..	..
34	Hamamelaceæ	2	2	..	2	..	2	1
35	Haloragæ	3	3	..	3	..	..	..
36	Melastomaceæ	1	1	..	1	..	..	..
37	Lythraceæ	4	4	..	4	..	..	..
38	Onagraceæ	5	10	1	11	..	..	..
39	Passifloraceæ	1	2	..	2	1	..	..
117 | 40	Cucurbitaceæ	1	1	..	1	..	..	..
41	Cactaceæ	1	1	..	1	..	..	..
42	Ficoideæ	1	1	..	1	..	..	..
43	Umbelliferæ	17	22	..	22	2	..	..
44	Araliaceæ	1	4	..	4	..	1	1
45	Cornaceæ	2	5	..	5	..	5	2
46	Caprifoliaceæ	5	12	..	12	3	10	1
47	Rubiaceæ	5	12	1	13	..	1	..
48	Valerianaceæ	2	4	..	4	1	..	..
49	Dipsaceæ	1	1	..	1	1	..	..
50	Compositæ	53	138	11	149	17	1	..
51	Lobeliaceæ	1	5	..	5	..	..	..
52	Campanulaceæ	2	2	..	2	..	..	..
53	Ericaceæ	11	24	2	26	..	17	2
54	Primulaceæ	5	8	2	10	2	..	..
55	Ebenaceæ	1	1	..	1	..	1	1
56	Oleaceæ	2	4	..	4	..	4	4
57	Apocynaceæ	2	2	1	3	1	..	..
58	Asclepiadaceæ	4	13	1	14	..	..	..
59	Gentianaceæ	4	6	..	6	..	..	..
60	Polemoniaceæ	2	6	..	6	..	..	..
61	Hydrophyllaceæ	3	4	..	4	..	..	..
62	Borraginaceæ	7	12	..	12	3	..	..
63	Convolvulaceæ	3	11	..	11	4	..	..
64	Solanaceæ	5	8	..	8	5	..	..
65	Scrophulariaceæ	15	32	..	32	5	..	..
66	Orobanchaceæ	4	4	..	4	1	..	..
67	Lentibulaceæ	1	2	..	2	..	..	..
68	Bignoniaceæ	2	2	..	2	1	2	1
69	Acanthaceæ	2	3	1	4	..	..	..
70	Verbenaceæ	3	6	..	6	1	..	..
71	Labiatæ	23	41	1	42	10	..	..
72	Plantaginaceæ	1	5	1	6	2	..	..
73	Amarantaceæ	2	5	..	5	4	..	..
74	Chenopodiaceæ	3	7	2	9	7	..	..
75	Phytolaccaceæ	1	1	..	1	..	..	..
76	Polygonaceæ	3	21	2	23	7	..	..
77	Podostemaceæ	1	1	..	1	..	..	..
78	Aristolochiaceæ	2	2	..	2	..	..	..
79	Piperaceæ	1	1	..	1	..	..	..
80	Lauraceæ	2	2	..	2	..	2	1
81	Thymeleaceæ	1	1	..	1	..	1	..
82	Santalaceæ	1	1	..	1	..	..	..
83	Loranthaceæ	1	1	..	1	..	1	..
84	Euphorbiaceæ	4	9	..	9	1	..	..
85	Urticaceæ	11	13	..	13	4	6	6
86	Platanaceæ	1	1	..	1	..	1	1
87	Juglandaceæ	2	7	..	7	..	7	7
88	Myricaceæ	1	1	..	1	..	1	..
118 | 89	Cupuliferæ	7	25	1	26	..	26	23

No.	ORDERS.	Genera.	Species.	Varieties.	Species and Varieties.	Introduced Plants.	Woody Plants.	Trees.
90	Salicaceæ	2	14	5	19	7	19	6
91	Ceratophyllaceæ	1	1	..	1	..	..	..
92	Araceæ	5	6	..	6	..	..	..
93	Lemnaceæ	1	1	..	1	..	..	..
94	Typhaceæ	2	3	1	4	..	..	..
95	Naiadaceæ	2	9	..	9	..	..	..
96	Alismaceæ	2	3	2	5	..	..	..
97	Hydrocharidaceæ.	2	2	..	2	..	..	..
98	Orchidaceæ	12	23	1	24	..	..	..
99	Amaryllidaceæ	1	1	..	1	..	..	..
100	Hæmodoraceæ	1	1	..	1	..	..	..
101	Iridaceæ	2	6	..	6	1	..	..
102	Dioscoreaceæ	1	1	..	1	..	..	..
103	Smilaceæ	1	6	..	6	..	4	..
104	Liliaceæ	18	24	..	24	5	..	..
105	Juncaceæ	2	8	7	15	..	..	..
106	Pontederiaceæ	3	3	..	3	..	..	..
107	Commelynaceæ	2	3	..	3	..	..	..
108	Xyridaceæ	1	1	..	1	..	..	..
109	Eriocaulonaceæ	1	1	..	1	..	..	..
110	Cyperaceæ	10	94	14	108	..	..	..
111	Gramineæ	43	104	6	110	26	..	..
112	Coniferæ	4	7	..	7	1	7	7
113	Equisetaceæ	1	2	..	2	..	..	..
114	Filices	16	29	1	30	..	..	..
115	Ophioglossaceæ	2	2	2	4	..	..	..
116	Lycopodiaceæ	2	5	1	6	..	..	..
117	Musci	42	98	..	98	..	..	..
118	Hepaticæ	23	29	..	29	..	..	..
119	Characeæ	2	4	..	4	..	..	..

119 | RECAPITULATION.

Groups.	Orders.	Genera.	Species.	Varieties.	Species and Varieties.	Introduced Plants.	Woody Plants.	Trees.
Polypetalæ	45	174	338	18	356	73	83	25
Gamopetalæ	27	169	368	21	389	57	36	9
Dichlamydeæ	72	343	706	39	745	130	119	34
Monochlamydeæ	19	47	114	10	124	30	64	44
Dicotyledons.	91	390	820	49	869	160	183	78
Monocotyledons.	20	112	300	31	331	32	4	..
Gymnospermæ	1	4	7	..	7	1	7	7
Phænogamia	112	506	1,127	89	1,207	193	194	85
Vascular Cryptogamia	4	21	38	4	42	...	...	..
Vascular Plants.	116	527	1,165	84	1,249	193	194	85
Cellular Cryptogamia	3	67	131	..	131	...	...	..
Total Flora	119	594	1,296	84	1,380	193	194	85

On this communication, Mr. C. A. WHITE remarked that he hoped Mr. Ward would be able to furnish some further information concerning the influence exerted upon a flora by the character of the country rocks. It is well known that the constitution of the strata, influencing as it does the character of the soils which cover them, had a further effect upon the native plants growing above them. Thus the granite localities of the east were more favorable to the growth of certain genera, for example, the Ericaceæ than the magnesian limestones of the Mississippi valley. He hoped that Mr. Ward might be able to ascertain how far these influences affected other families of plants.

Mr. POWELL inquired what were the characters or character of plants that had apparently disappeared from the local flora in the comparison of the field results of the present time with those obtained forty or fifty years ago.

Mr. WARD replied that the missing species in the present lists were not confined to any particular family, but were diffused considerably among the several classes.

December 28, 1881—Ætat. 40.

117. Sketch of Professor John W. Powell (with portrait).

History.—Written June 9 to July 20, 1881. I proposed to Major Powell on May 12th the writing of a sketch of his life and career. "He feigned considerable modesty about it, but I gathered that I could go ahead. So I have written a letter to Youmans" [note made on that date]. On the 21st I received a reply asking me to write the sketch. On the 25th I had a long interview with the Major, and he gave me many points relative to his early explorations. I submitted the outline to him on July 4th for revision. Mr. J. C. Pilling also revised it. Major Powell gave me a photograph for the portrait. I sent on the whole matter before leaving for the field on the 26th.

The Popular Science Monthly, New York, Vol. XX, No. 3, January, 1882, pp. 390–397. Portrait, frontispiece to the January number, facing p. 289.

PROFESSOR JOHN W. POWELL, better known as Major Powell, Ph.D., founder and director of the Bureau of Ethnology of the Smithsonian Institution, and present director of the United States Geological Sur-

JOHN WESLEY POWELL.

vey, is a pattern of the American self-made man, and well illustrates in his life and achievements what may be accomplished with honest, steady adherence to a definite purpose. He was born at Mount Morris, New York, on the 24th of March, 1834, a short time after the arrival of his parents from England. His father was a Methodist clergyman, and was required to lead a very unsettled life. In his early childhood the family removed to Ohio; eight years afterward, to Wisconsin; and again, when he was fifteen years of age, to Illinois, where young Powell remained most of the time until the breaking out of the war.

It was during this latter period that his mental characteristics were developed. He was eager for knowledge, and used every opportunity to pursue such courses of study as were accessible to him, or appeared to be adapted to his case. He studied for a time at Illinois College, Jacksonville, and subsequently entered Wheaton College. Unable to attend school continuously, he alternated between teaching in the public schools and studying, and in 1854 he went to Oberlin to pursue a special course of two years.

From the first he was strongly attracted to the natural sciences, and particularly toward natural history and geology. He was fond of making collections, which he studied for their own sake. He commenced with botany, to which he has made some valuable contributions. Being much interested in nature, he acquired a roving disposition, and lost no opportunity of making scientific excursions, sometimes extending to long journeys. Having already made journeys on the Mississippi to St. Paul and across the State of Wisconsin to Mackinaw, in 1856 he descended the Mississippi River in a skiff and alone from the Falls of St. Anthony to its mouth, making collections, which he gave to the various museums of the State institutions. The next year he rowed from Pittsburg to the mouth of the Ohio, | and spent the fall in Missouri, studying the geology and mineralogy of the Iron Mountain region. In 391
1858 he made a trip from Ottawa, Illinois, down the Illinois

River to its mouth, and later ascended the Desmoines River, returning laden with specimens.

The various institutions of the State of Illinois, and some of other States, soon came to depend upon his collections for illustrating their courses of scientific lectures, and the Illinois State Natural History Society elected him its secretary, and extended to him facilities for prosecuting his researches, now recognized as of high value. The funds necessary for conducting these operations he was obliged to obtain by teaching a portion of each year.

The breaking out of the rebellion put a temporary check upon Professor Powell's scientific adventures. He enlisted as a private in the Twentieth Illinois Infantry. Having been made a lieutenant, he was transferred to Battery F, Second Illinois Artillery, and was afterward promoted to be captain of the battery, then major of the regiment, and finally lieutenant-colonel. In the last days of the war he received a commission as colonel, but, having no desire to follow war as a profession, declined it.

At the battle of Shiloh he lost his right arm. As soon as he had sufficiently recovered from his wound he returned to his post, and continued to serve to the end of the war.

His passion for collecting did not forsake him even while in the army, and wherever he was stationed for a sufficient length of time he found means of studying the geological formations, and of shipping from time to time to the State Museum large invoices of valuable material.

On his return from the army he was offered a lucrative civil position in his own town of Wheaton, but he preferred to accept the comparatively unremunerative one of Professor of Geology and Curator of the Museum of the Illinois Wesleyan University at Bloomington. This he afterward exchanged for a similar post in the Illinois Normal University.

In the summer of 1867 Professor Powell, taking with him his class in geology, visited the mountains of Colorado for the purpose of study. This excursion was the first attempt

of its kind in this country, and to Professor Powell is therefore due the credit of having inaugurated a practice of the highest value to science and to education, which has been continued by many eminent teachers at leading institutions, until a certain amount of field-study has become recognized as a necessary part of a course of instruction in all branches of natural science.

Professor Powell saw more in the parks and cañons of Colorado than a mere training-school for students. He saw, stretching far westward and southward, a vast unexplored region, hitherto represented on all maps by an utter blank, and through which at some point must flow an immense river, the Colorado of the West, whose | upper tributaries and lower portion were alone known to civilized 392 man. That such an unexplored region should exist within the limits of the United States seemed to him almost a reproach to the boasted enterprise of our people, and he began to lay plans for its exploration.

In the summer of 1868 he organized a party of men, some of whom were mountaineers, and, starting from Middle Park, followed down the Grand River to the head of Cedar Cañon, thence over the Park Range through Gore's Pass to the White River, one hundred and twenty miles above its mouth. Here the party went into winter-quarters, and during the winter made reconnaissances, and completed their preparations for an early expedition in the spring.

Proceeding, in the spring of 1869, to Green River station, on the 25th of May the expedition launched its four small craft in Green River, the largest of the tributaries of the Colorado.

We have not space to follow them through their perilous voyage of over three months' duration, or to describe the succession of hardships, disasters, and hair-breadth escapes, by which almost every day of this period was characterized. All this has been written by the hero of the expedition. We can only say here that it was not until the 20th of July that the brave party reached the junction of the Grand and

Green, or the head of the Colorado River proper; that on the 13th of August they entered the Grand Cañon, from which they did not emerge until the 29th; and that on the 30th of that month they at last arrived at the mouth of the Rio Virgen, where, for the first time, they saw the faces of white men.

After having been two weeks in the Grand Cañon, already for some time reduced to half-rations, three of the men refused to go farther, and endeavored to induce Major Powell to turn back. He explained to them that they were very near the end of their journey, but was himself almost tempted, in view of the scarcity of provisions, and the probable nearness of Mormon settlements, to yield to their arguments. He passed a sleepless night, and expresses the result of his reflections in the following words: "But for years I have been contemplating this trip. To leave the exploration unfinished, to say that there is a part of the cañon which I can not explore, having already almost accomplished it, is more than I am willing to acknowledge, and I determine to go on." The three men undertook to reach the settlements by a journey across the country, and were murdered by Indians; the boatmen emerged the next day in safety from their granite prison.

This daring voyage was not a barren adventure. In many respects it was a scientific expedition, and as many instruments as could be taken were carried, and determinations were made wherever practicable, the accurate records of which were kept in duplicate, so that one set was safely brought through. The importance of Professor Powell's labors, and their thorough and scientific character, made it apparent that they should be followed up, while their national bearing sug | gested to Professor Henry, of
393 the Smithsonian Institution, the propriety of asking the Government to lend its assistance.

Accordingly, a topographical and geological survey of the Colorado River of the West and its tributaries was inaugurated by Congress and placed under Professor Powell's direction.

With these added facilities the exploration was pushed from year to year with great energy and success, and a systematic survey was conducted, until all the streams, mountains, plateaus, and other physical features of the Colorado Valley, embracing an area of nearly one hundred thousand square miles, have become thoroughly known topographically and geologically, and there is no longer an unexplored region within the confines of the United States. In 1875 Professor Powell published some important chapters "On the Physical Features of the Valley of the Colorado," which, while dealing largely in the physical geography of the country, were in the main geological, and set forth for the first time the fundamental principles that underlie the structural formation of a large part of the Rocky Mountain region. The next year appeared his "Geology of the Uintah Mountains," which is likewise a model of clearness, and consists in a careful analysis of the laws which have operated in the formation of these masses; while much of the consistent reasoning from the closely observed phenomena of this region is equally applicable to all parts of the West.

So great was the general interest at this time in acquiring an accurate acquaintance with the Western portion of the country, that no less than four authorized surveys were operating simultaneously in the different Territories. These were: 1. The special survey of the fortieth parallel, under the War Department, in charge of Mr. Clarence King, organized in 1867; 2. Dr. F. V. Hayden's geological and geographical survey of the Territories, organized and operating under the direction of the Secretary of the Interior since 1867; 3. A military and topographical survey, conducted by Lieutenant G. M. Wheeler, under instructions from the Chief of Engineers of the War Department, organized in 1869; and 4, and last in chronological order, that of Major Powell, which received its first national aid in the year 1870, although, as we have seen, it had been in the field as a private enterprise since 1868.

These various expeditions became to a great extent rivals, and, being not only independent of each other, but conducted by different departments of the Government, it was impossible to avoid the duplication of much of the work, or to prevent the growth of discordant methods. Occasional collisions occurred between parties of different surveys in the field, bitter feelings were engendered, and the two departments under which the parties were serving found themselves called upon to defend their jurisdiction and claims to the right of conducting public surveys.

The attention of Congress was called to the matter, and on the 15th | of April, 1874, the House of Representatives adopted a resolution asking information from 394
the President respecting the surveys that were operating in the same and contiguous areas of territory west of the Mississippi, and whether it would not be practicable to consolidate them under one department, or to define the geographical limits to be embraced by each.

The President's message in reply to this resolution was accompanied by a report from the Secretary of War, who transmitted the views of the Chief of Engineers, and one from the Secretary of the Interior, transmitting in like manner sub-reports from the heads of the respective surveys under his superintendence, viz., Hayden and Powell. Upon the question of consolidating all the surveys then in operation under one department, but one opinion was expressed, all being in favor of such a measure; but, as to which department should control them, the views were discordant —the President, the Secretary of War, and the Chief of Engineers, urging the claims of the War Department, and the Secretary of the Interior and both the heads of surveys under his direction as firmly advocating the fitness of that department to administer them. The War Department claimed this right by a sort of *prescription*, as it was under its protection and control that all the early explorations, including the celebrated expedition of Lewis and Clarke, had been conducted, and by it the leading object was

declared to be the accurate mapping of the country for military operations. It also claimed a higher scientific training and discipline for performing the work.

The Department of the Interior, on the other hand, connected the surveys primarily with the public domain, and showed that they were chiefly ancillary to the operations of the Land-Office, which had always been under that department. It also maintained that even in the expeditions under the Engineer Corps civilians had always performed the bulk of the scientific work.

The committee to which the reports were referred recommended that the surveys under the War Department should be continued, so far as they were necessary for military purposes, and that all other surveys for geographical, geological, topographical, and scientific purposes should be continued under the direction of the Department of the Interior.

This report left matters nearly where they were, and was not satisfactory to either party. A second inquiry was ordered by the House in March, 1878, and the officers immediately charged with the surveys were again called upon to express their views on the subject. Major Powell, in his statement, pointed out the essential vices of the multiple surveys; proposed that each branch of natural history should be prosecuted wholly by some one of the divisions, which should be in possession of all the materials; offered to turn over to Dr. Hayden all the materials in his possession relating to any or all of these branches, | or to receive
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and elaborate the materials collected by other surveys; and pointed out the different methods by which the work of surveying was performed by the parties of the War and those of the Interior Department, and the impossibility of ever completely harmonizing them. He also presented a map, showing the amount and location of the duplicated work. His paper concludes with these remarks: "If the surveys of both departments are carried on over the entire region, there will be two general atlases of the whole area,

and the work will be twice done. If the surveys are confined to different areas, there will be an Interior Department atlas of one region and a War Department atlas of the other, and neither atlas can be completed for the entire region without reconstructing the maps of the other. In view of these facts, it is manifest that the work should be unified and a common system adopted. This may be accomplished either by an act of Congress, by executive direction, or by placing the work under one management."

The improbability that, in case of consolidation, Professor Powell would be called to the head of the surveys, as well as the known sincerity of his personal character, precluded suspicion of any other motive for such an expression of views than that of concern for the interests of the service.

A provision was inserted in one of the appropriation bills, requiring the National Academy of Sciences to take into consideration "a plan for surveying and mapping the Territories of the United States on such general system as will secure the best results at the least possible cost." Professor O. C. Marsh, president of the academy, and chairman of the committee appointed by it to consider the subject, requested the Secretaries of War and of the Interior to furnish the committee with any data at their disposal to aid it in performing the duty thus imposed upon it. Both secretaries responded through their chosen representatives, Professor Powell, with Dr. Hayden and Commissioner Williamson of the Land-Office, appearing for the Interior Department. Professor Powell's paper was even a more clear and complete statement than the one he had made before the congressional committee, of the necessity of consolidating the surveys and making a division of the labor on a scientific basis. On the 26th of November the National Academy submitted its report, on the basis of the one that had been made to it by its committee, recommending the establishment, under the Department of the Interior, of an independent organization, to be known as the United States Geological Survey, to be charged with the study of the geo-

logical structure and economical resources of the public domain, the director of which should be appointed by the President. A provision organizing the survey, in accordance with these recommendations, was passed by Congress in an appropriation bill.

Professor Powell supported Mr. Clarence King, who was appointed | for the position of director of the survey, and was himself placed upon the commission on the 396 codification of existing laws relating to the survey and disposition of the public domain.

The labors of this commission concluded, Professor Powell was glad to be able to turn his attention once more to science. The one field which now most deeply interested him was that of American ethnology. From the very beginning of his Western explorations, the aborigines had strongly engrossed his thoughts, and among all his scientific collections and investigations which he had been enabled to make none had received more careful attention than those relating to the Indian tribes. While the other surveys had devoted much attention to the collection, study, and illustration of the various departments of natural history, he had made ethnography, next to geology and topography, the chief object of this expeditions. Prior to the date of the consolidation, three volumes relating to ethnology had been published by the Powell Survey, and eight more were in different states of preparation, while in addition to this the material collected and deposited in the Anthropological Hall of the Smithsonian Institution was sufficient for several other volumes, and demanded elaboration. The study of Indian languages had especially interested him, for he saw that, whatever success might be attained in preserving the Indians themselves from extermination, the fate of their languages was already settled, and in a short time the primitive stocks would have inevitably become so badly corrupted that the philologist would find it impossible to deal with them in a scientific manner.

Efforts were made by the Secretary of the Smithsonian

Institution and the Secretary of the Interior to prevent the discontinuance of this work, and an appropriation of twenty thousand dollars was secured in March, 1879, for completing and preparing for publication the "Contributions to North American Ethnology," under the Smithsonian Institution, with a provision that all the material collected in the surveys that bore on that subject should be turned over to that institution.

Professor Powell was put in charge of this department, and has prosecuted it with great vigor and success to the present time. A Bureau of Ethnology grew up under the Smithsonian Institution, which has become the recognized center of ethnographic operations in this country.

When, in the spring of 1881, Mr. Clarence King retired from the work of the surveys, there seemed to be no rival candidate to Professor Powell for the vacant position, and it fell to him as the most obviously suitable person to fill it.

Without mentioning particularly the numerous official reports into which important scientific matters have often found their way, the principal literary contributions of Professor Powell are the following:

1. "History of the Exploration of the Cañons of the Colorado." | This work, which was published in quarto
379 form and illustrated, as Part I (Chapters I to IX) of the original volume of "Exploration of the Colorado River of the West and its Tributaries, explored in 1869, 1870, 1871, and 1872, under the Direction of the Smithsonian Institution" (1875), consists of the personal narrative, from Professor Powell's diary, of the celebrated voyage down the unexplored river.

2. "On the Physical Features of the Colorado Valley." This forms Part II of the same work.

3. "Geology of the Uintah Mountains, with Atlas" (1876).

4. "Introduction to the Study of Indian Languages, with Words, Phrases, and Sentences to be collected" (1877).

5. "Report on the Lands of the Arid Region of the United

States, etc., with Maps" (1879). This is a highly important public document, and one with the contents of which the country generally should be familiar. Though containing able chapters by Mr. G. K. Gilbert, Captain C. E. Dutton, Professor A. H. Thompson, and Mr. Willis Drummond, Jr., it is, in its general plan and in the chief part of its matter, the work of Professor Powell.

6. "Introduction to the Study of Indian Languages, etc. Second edition—with Charts" (1880). We enter this work as distinct from the first edition, published in 1877 under the same title, because, with the exception of the schedules, notes to collectors, and remarks on the alphabet, its matter is wholly new. Though small, it is one of the most important of Professor Powell's contributions to science.

Professor Powell is a member of the National Academy of Sciences and a Fellow of the American Association for the Advancement of Science, and presided over the Biological Section of the latter in 1879. He has been the President of the Anthropological Society of Washington since its organization, and his annual addresses before it are published in its "Transactions."

Personally, he is of most agreeable manners, frank, genial, and cordial under all circumstances, and possessed of great individual magnetism. Though social by nature, he has a strong preference for persons of culture, and especially of independence of thought, as his friends, and seems to possess the tact of securing such without giving offense to others. It is a favorite theory of his that, to observe well, one must also think deeply, and that observation without theory is necessarily sterile; and these ideas he carries into practical affairs in the selection of his assistants in all branches of his service. His mind is in the highest degree realistic, and he looks upon all classes of phenomena from the objective point of view. In anthropology he belongs to the strictly scientific school, represented by Mr. Lewis H. Morgan, which rejects the imaginative and poetical accounts of the

lower races. He accepts the doctrine of evolution, but has not failed to perceive inadequacies in the systematic developments which some of its disciples have sought to make of certain of its minor details.

118. On the Cause of the Absence of Trees on the Great Plains[1]

History.—Written November 6 to December 9, 1881, at which latter date it was read before the Biological Society of Washington. It was rewritten December 28, 1881, to January 30, 1882, and sent to press on January 31, 1882.

The Kansas City Review of Science and Industry, Kansas City, Mo., Vol. V, No. 11, March, 1882, pp. 697–702.

THE many fine-spun and often puerile theories that have been advanced by men of greater or less scientific reputation to account for the treeless condition of a large part of our country, are responsible for the continued prominence of this old and familiar question. The latest utterance on the subject comes from Prof. Thomas Meehan in the form of a "Note on Treeless Prairies,"[2] in which, to his credit be it said, he has undoubtedly given the proper solution to the problem, so far as the proper "prairies" are concerned, namely, that they are due in the main to the annual fires that have from time immemorial swept over these areas. This conclusion, however, is far

[1] Read before the Biological Society of Washington, December 9, 1881.

[2] Proc. Acad. Nat. Sci., Phila., Feb., 1881.

less fresh than the language in which it is announced would imply that he regarded it. Dr. C. A. White, then State Geologist of Iowa, in his annual report for 1870,[1] expresses his view as follows: "It now remains to say, without the least hesitation, that *the real cause of the present existence of the prairies in Iowa is the prevalence of the annual fires.* If these had been prevented fifty years ago, Iowa would now be a timbered instead of a prairie State"; and Dr. Alexander Winchell remarks[2] that "The old and popular belief was that which attributed their treelessness to the annual burning of the grass by the Indians."

Born and raised in the prairie region, I can fully confirm the testimony of these two Western men, and add that this explanation was the only one that I am aware of having ever received any serious attention from the class of practical people whom I was accustomed to hear speak on the subject; all others being dismissed as the efforts of over-learned persons to give some other reason for things than that dictated by plain common sense. The formal ratiocination by
698 | which Prof. Meehan establishes his conclusion was as familiar to my childhood as the alphabet, and its extreme simplicity is virtually acknowledged by him a few lines lower on the same page, where, speaking of Indians, he admits that "Low as their power of reasoning may be, they could not but have perceived that while grassy herbage throve in spite of fires, perhaps improved under the fiery ordeal, trees could not follow on burned land. What could be more natural than that they would burn the prairies with the object of retaining food for their wild animals." Certainly what savages could reason out *a priori*, white men ought to be able to account for *a posteriori* with all the data at hand; and this they certainly have done from the first, and refused to be befogged by any of the other specious reasoning already referred to.

[1] Vol. 1, p. 133.
[2] Sketches of Creation, 1874, p. 266.

But the problem of the "grassy prairies" and the problem of the Great Plains are not identical. When we extend our inquiries to embrace the broad expanse that stretches westward from the Missouri and the western boundary of Arkansas to the base of the Rocky Mountains, we encounter a new class of phenomena which require to be accounted for on a different principle.

The investigation is, however, seriously complicated by the fact that between the very distinct conditions that characterize the typical prairies and the typical plains there is geographically no precise line of demarkation, the one passing into the other by rigidly insensible gradations.

In traveling westward from Kansas City or from Omaha, one passes through an almost completely treeless region for a distance of five or six hundred miles. A careful observer will, however, perceive that the eastern portion of this great plain differs in many respects from the more central or western portions, and that it may therefore be divided into two general areas, which, however, blend together and do not admit of being clearly marked off from each other. If it could serve any useful purpose to draw an arbitrary line to denote approximately the western boundary of the one and the eastern boundary of the other, this line might perhaps be made to coincide with the 100th meridian, which passes through western Kansas and central Nebraska. For a moderately limited north-and-south range, this line does not fall far from that represented by an altitude of 2,500 feet and an average annual rain-fall of twenty inches.

In point of fact, as regards this latter, which is of chief importance to our subject, the twenty-inch isohyetal, if followed southward from the Missouri River, which it crosses at a point near Yankton, or about on the 98th meridian, bears westward and touches the Kansas and Nebraska State line almost exactly at the 100th meridian. It continues slowly to bear westward and reaches the 101st meridian at the southern boundary of Kansas, crossing it, but returning

to it at the Rio Grande, which it follows thereafter very closely to near its mouth.

This line as thus described would, therefore, still more nearly represent the imaginary boundary of these two treeless areas.

As we approach this line, proceeding westward, the grassy character of the plains gradually disappears, the typical prairie vegetation is changed and gives place to a new class of plants which are for the most part represented by three
699 | dominant types: 1st. Those having thick succulent stems for storing up moisture, of which the cactuses are the best examples. 2d. Those having large and deep roots, such as *Ipomœa leptophylla*, the bulk of which is really subterranean; and 3d. Those having either glandular, hairy or woolly surfaces, belonging to numerous families, but chiefly to the *Compositæ*, the *Borraginaceæ*, and the *Leguminosæ*. Large interspaces of bare ground occur between the more and more sparse occupants of the soil; grass, when seen at all, appears in small, disconnected bunches; the face of the country assumes a dull, leaden hue, and the transition at length becomes complete.

A sojourn upon the plains for a short period reveals other marked peculiarities. The eastern sky is frequently seen lit up on summer evenings by flashes of lightning, and by day a bank of cloud may often be observed hanging low along the eastern horizon while all is dry and arid at the observer's station. Or, looking to the westward, heavy showers may be seen to gather upon the mountains, only to thrust a few spent cloud-columns over the parched regions below.

The prime cause of the changes in the vegetation above pointed out is therefore of course not far to seek. The scanty rain-fall would seem alone sufficient to account for it. After passing the western boundary of Kansas, the annual precipitation is but sixteen, and falls as one proceeds farther westward to twelve inches. The same is true throughout western Nebraska and Dakota and eastern Montana.

At Denver it is 14.09; at Cheyenne, 13.77; at Fort Lyon, Col., 12.56; at Fort Stevenson, Dak., 11.84, and at Fort Rice, Dak., 11.39 inches.

Any country whose annual rain-fall is less than ten inches is a true desert, and we see how closely this great region approaches this condition at certain points. It is only rarely, and this either in natural depressions or in the vicinity of rivers, that green patches of buffalo grass, *Bouteloua oligostachya* or *Buchloë dactyloides*, may be seen, possessing anything that can be called turf, and the face of the country has, to a large extent, the general aspect of a desert.

But if this deficient rain-fall accounts for the absence of grass and the other herbage characteristic of the East, is it sufficient also to explain the absence of trees? And if so, why is the country not timbered out to near the 100th meridian?

The first of these questions should, I think, be answered affirmatively. As to the second, it has already been answered at the beginning of this paper. It is, I believe, indeed true that there are no trees on the plains because they will not grow there, and it may be this opinion (which *is* somewhat prevalent), that Prof. Meehan has confounded with a similar explanation of the more eastern prairies; for at the beginning of his paper he remarks that "The most prevalent belief had been that trees would not grow on these prairies," a statement which is very wide of the truth for the prairies proper.

This view may be substantiated by a few facts:

1. It is not possible to account for the absence of trees on the plains on the theory of fires. Fires do indeed occur but not frequently or extensively. The vegetation is scarcely dense enough to support them. The testimony is conflict|ing with regard to their extent and frequency 700
even among those who have lived many years on the plains. My own inquiries, made of such persons, confirm the above statement.

2. All successful attempts to make trees grow on the

plains have been made in irrigated districts, which is of course no test of their ability to grow in districts not irrigated. At least one unsuccessful attempt has been made, viz., that of the Kansas Pacific Railroad Company, to plant them along their line.

3. It is true that three cottonwoods, *Populus monilifera*, *P. balsamifera*, and *P. balsamifera*, var. *angustifolia*, grow spontaneously along the valleys of streams in some places, one of which, *P. monilifera*, is often found far out on the plains. These, however, rather substantiate than disprove the theory here advanced, since, if the timber were destroyed by fires, the cottonwoods would share the common lot of all. In fact they furnish still stronger proof against the fire theory, for where they are found is just where the most grass grows, and hence where the fires would be most frequent and destructive. It is therefore safe to say that the general absence of arborescent vegetation is not due, as on the more eastern prairies, to annual fires.

To say that the distance from actual forests is too great for trees to migrate over the plains, would be not only to misapprehend the question, since they would have been there from the first, but would be to betray ignorance of the facility with which vegetation is known to traverse vast areas and find its way across continents, and even hemispheres of the globe. No point on the plains is too remote for the cottonwood to fail to reach it, provided the conditions for its growth exist, and if it be said that the peculiar anemophilous seed of this genus adapt it above other trees for finding a proper habitat, it may be replied that few other trees live in such small areas, so widely separated from one another as to require similar devices for scattering their seed. If the entire plain was capable of supporting a general forest growth, such as once existed in the Eastern States, the individuals of any species would be in such close proximity to each other that propagation by the ordinary methods would be as easy there as here.

The whole subject may therefore be briefly summed up as follows:

Since the elevation of the Rocky Mountain range at the close of the Tertiary age, the atmosphere, in the general easterly movement which it possesses at all latitudes within the United States, has at all times lost the greater part of its moisture by condensation upon the cold summits of these and the more western ranges, so that by the time it reaches the great plains it is too dry for precipitation except under unusual conditions. As it moves still farther eastward across a level country, having river valleys and lake basins, it comes in contact with currents from the north, the south and the east, brought there by the constant disturbances of barometric pressure with which all are acquainted, and in this manner it gradually becomes at length again sufficiently laden with moisture to yield portions of it to the soil when condensed by currents of unlike temperature. This characteristic becomes more and more marked with the eastern movement until the Mississippi Valley is reached, in which and at all points eastward the rain-fall, varying from thirty-two to sixty inches, is sufficient to be depended upon for agricultural purposes. 701

Where the annual precipitation is below twenty, or perhaps twenty-four inches, there can be no growth of forests, and this is the true cause of the absence of trees on the great plains. But this does not prevent the existence in arid regions of certain specialized types of arborescent vegetation. The sage brush that covers the dreary wastes of the Rocky Mountain Region, the Laramie Plains, the Bitter Creek Valley, and such vast areas of the West, while in its botanical characters it is little more than an over-grown weed, is to all intents and purposes a tree, and often attains a great age. The region it occupies is even more arid than the great plains, yet no fires occur and no forests grow. In the nearly rainless areas of Arizona, southern Utah and New Mexico, and stretching eastward into Texas, there occur a number of arborescent forms, the creosote bush (*Larrea Mexicana*),

the mesquit (*Prosopis juliflora*), various acacias and mimosas, and one yucca (*Y. brevifolia*), together with the tree cactus (*Cereus giganteus*). These grow scattered at great distances from each other and rarely form thickets or groves. Why no such characteristic species are found occupying the great plains is not known, and it is probably a mere accident that none happens to exist, adapted both to their temperatures and their arid condition. Did any such exist, there seems no reason why it might not thrive as well as the sage brush farther west or the mesquit of the south.

The absence of forests or extensive tracts of timber land on those areas of our western country where the rain-fall annually exceeds twenty-four inches, must, as already remarked, be attributed to human agency in repeatedly burning over these areas, whereby all forms of vegetation requiring more than one season to mature their fruit are prevented from perpetuating their kind. The American aborigines have inhabited this continent through a prolonged period of the past, how long we need not here stop to inquire. Ages prior to European discovery they roamed over the great plains, hunting the buffalo, and through the forest-clad wildernesses to the eastward, hunting the deer, the elk, and the other large animals that belonged to the fauna of the country. Doubtless they found it advantageous to locate themselves at points near the boundary line which separates these great areas, so well marked off by nature, where they could pursue the antelope by going westward or the deer by going eastward.

No human race has yet been found so low as to be ignorant of the art of making fire, and all along this border of the forest region we may imagine the red man's camp-fire to have glowed in periods too remote for profitable speculation. It is wholly unnecessary to assume, as Prof. Meehan has done, that the grass of these border wood-lands was fired intentionally or "with the object of retaining food for their wild animals." It is just possible that their knowledge that wild animals would be attracted to the sweeter grasses

of newly burned tracts, may have led to the intentional burning of certain districts, but there is no need to call in this partial explanation. No Indian would ever attempt to check the ravages of fires accidentally allowed to escape, or prevent them from plunging into the forest. Every one knows that this is constantly occurring 702 in the camps of civilized men, who are responsible for the fact that in the regions over which they have displaced the Indian for nearly a century no growth of timber has yet been allowed to spring up as is its natural tendency. How much less, then, would savages restrain the agency of fire in reducing the forests of the Missouri and Mississippi Valleys to the treeless condition of the plains!

The prevailing winds throughout the entire section under consideration are from the west, and it is easy to see how, in a few centuries at least, the prairies of Kansas, Nebraska, Iowa, Missouri, and Illinois might have resulted from this continuous holocaust of their pristine forests.

The very simplicity of scientific truths is often a bar to their acceptance, but science, as Huxley has said, is only common sense methodized and extended. Certain investigators seem to suppose that unless their labors succeed in bringing out some unexpected result no progress has been made. No problem has been more completely in the hands of this class than that of the timberless regions of North America.

This form of sensational science should be discountenanced as tending to warp the candid judgment of students of nature, and to divert them from the one sole aim of science, the discovery of truth.

If, therefore, in considering the facts from which the causes of the absence of arborescent vegetation upon the great plains must be deduced, I have reached a somewhat plain and commonplace conclusion, my only apology must be that no other conclusion has seemed to me to be warranted by those facts.

119. Guide to the Flora of Washington and Vicinity.

History.—Written January 2 to June 20, 1881.

As this is not only my first but my only botanical contribution of the dimensions of a book, its history is practically that of my botanical work excepting that done outside of this region, and that consists chiefly of my work in Utah in 1875. I had always taken an interest in botany, but perhaps not greater than in other branches of natural history. That I should have specialized in it, after taking up ornithology and to some extent other branches of zoölogy, is due entirely to the greater facility with which I found I could pursue it, situated as I was. My early life was passed in close contact with nature, and I had a great fondness for both plants and animals, but I had never had an opportunity to study either scientifically. At college botany was taught by a chemist from Gray's *Lessons*, which I studied and recited without seeing a plant! As my mind was then mature I, of course, saw its absurdity, and I find that on February 24, 1869, I purchased a copy of the Fourth Edition of Gray's

Manual, hoping, with the opening of spring, to be able to make some excursions and study plants at first hand. But for unknown reasons I did not do so, nor yet the next year, but on April 15, 1871, I bought some kind of a microscope, and the next day made a "botanical excursion," and triumphantly recorded the identification of the dogwood and the buttercup, giving their Latin names correctly! This was not repeated that year, but the next spring, commencing on April 21 (1872), I entered upon my regular series of collecting tours, identifying all the plants I collected, and preserving them in some way. On May 2d, I bought a blank book in which to record results. I called it a "Botanical Note-book and Journal," and also made it a "Chronological Catalogue." On the first page I wrote: "Journal of Botanical Researches;" and I entered the name of each plant with the date of collection, and gave each a number. I also recorded the locality. I may say here that this system was kept up till June 21, 1885, and the last number is 1379. This is only five less than the whole number in the *Check List* when published in 1881, and which includes many plants not collected by me.

I had nothing but a "reticule" to carry my plants in, and I had heard that botanists used a tin box for the purpose; so the next spring (1873) I had one made and used it most of that summer. But I soon learned the superiority of the portfolio, and never used the box after that year. Then the problem arose what to do with the plants. I had

been putting them into something that I called a "herbarium," but it must have been a very rude affair. So I ordered one of those fancy books that are sold for the purpose, and Mrs. Ward pasted the plants into that. It was soon full, of course, but they looked well, and I wrote the names under them, the idea of labels not having yet occurred to me. This "herbarium" I still possess.

In 1873, I think it was, an association was formed in Washington called the Potomac Side Naturalists' Club. I heard of it on May 20th of that year, but I was wholly unknown, and had no part in organizing it. On December 8th, however, I began to attend its meetings, and from that date I was a somewhat prominent member as long as it continued in active existence. On March 2, 1874, the question came up of preparing a new catalogue of the plants of the District of Columbia, and the several botanical members of the Club were assigned sections to elaborate. We were left mostly to make our own selections, and I chose the department of trees. The Club continued to meet during the spring and fall of 1874. I was already able to bring many specimens of plants hitherto unknown to the flora, and on field excursions that were made I frequently took the members to the localities where they grew. My collection had now become quite large and I kept my plants loose in newspapers. During the summer and autumn I had some labels printed to put with them. In the house I had been building I had one room fitted up exclusively for scientific uses, and

in the fall I had regular herbarium cases put in. Then I ordered herbarium paper and genus covers and commenced putting my herbarium into systematic order. By the end of 1874 I had catalogued 758 species.

With the year 1875 I introduced an additional feature into my botanical work. While keeping up the chronological catalogue, I commenced a "Botanical Note-book" in which I recorded all my field excursions in detail and noted all the peculiarities that I detected in the plants. I recorded a number of excursions in this way before I left for a five-months' campaign in Utah to collect the woods of that region for the Centennial Exposition, but during which I made an extensive collection of plants of all kinds. The record of all this was kept in another book. On my return in September I resumed my local rambles. Before I left, the work of mounting the plants had been begun, and this was mostly done by Mrs. Ward. We began with the glue-pot, but soon changed to the gummed strips, which proved far more satisfactory. In my field work I was always thinking, and in the winter of 1874–5 I had drawn up the main heads of my paper on the "Local Distribution of Plants" (see *supra*, No. 78). They had asked me to read a paper before the Potomac Side Naturalists' Club, and on March 29th I gave them that.

Besides the specimens that I had mounted there were of course many duplicates, as I had made it a rule, where possible, to collect ten specimens of

everything. I was already contemplating extensive exchanges with botanists in other parts of the country who had plants that did not grow in the vicinity of Washington, and on April 1, 1875, I commenced checking catalogues in the customary way to indicate both duplicates that I had for exchange and desiderata, or plants that I wanted to obtain by exchange.

After my return from the West I devoted myself almost exclusively to the study of the oaks from the acorns, usually from the same trees from which I had obtained aments in the spring, and on October 18th, I laid my results before the Club (see *supra*, No. 73). Later on I made a study of the pith of poison ivy, and explained this to the members in January and February, 1876 (see *supra*, No. 75). I continued my botanical investigations through the spring of 1876, and on May 8th I gave some kind of a report upon them to the Club, the exact nature of which I do not remember. The other botanists (Dr. Vasey, Professor Chickering, Dr. Foreman, and Mr. Seaman) were at work on the catalogue. In 1830 Dr. John A. Brereton, U. S. Army, had published the *Floræ Columbianæ Prodromus, exhibens Enumerationem Plantarum, quæ hactenus exploratæ sunt: or a Prodromus of the Flora Columbiana, exhibiting a List of all the Plants which have as yet been collected.* It was based on the Linnæan system, and it was proposed to republish it on the natural system with all needed changes of names and as many additional species as had been discovered.

This committee, of which I was the fifth member, held a few meetings and endeavored to decide what plants to include. I was so new to the science that I did not often venture to make a suggestion further than to bring forward specimens that I had myself collected. But as a sort of spectator at these committee meetings I became thoroughly dissatisfied with the method pursued. When a name was proposed I would hear such remarks as this: "That plant ought to be here. I have seen it in Baltimore or Philadelphia, or New England, etc.," and into the catalogue it would go. I said to myself, "Such a catalogue will be worthless in exchanging. Parties will be constantly asking for plants that we cannot supply." And so it proved. The list as thus made up was published in instalments in *Field and Forest*, the organ of the Club, and then issued in complete form. It appeared in 1876, and bore the following title: *Flora Columbiana, or Catalogue of Plants growing without cultivation, collected by Members of the Potomac-Side Naturalists' Club, in the District of Columbia and its immediate Vicinity. Washington: Columbia Press. 1876.* The species are numbered, and the last number is 1083. It is a mere check-list, localities not being given. I devoted one copy of it to my special use, by having my chronological numbers transferred to it and placed in front of the printed numbers. I found that I already had a large number not included in the catalogue. Other botanists made additions, and they were all gotten together into a list of addenda.

At the end of 1878 there were further additions, and both were then published on a single leaf convenient for slipping into the catalogue. My copy has this feature with my numbers added. All this work of transferring the numbers was done by Mrs. Ward, and the figures are in her handwriting. It took her several weeks to complete it, but it was very useful to me. In 1877, I made my large Texas collection (see *supra*, No. 96), and there were many duplicates of these for exchange. It was therefore necessary to prepare a manuscript list of all duplicates not in Mann's Catalogue. A list of my desiderata from Mann's Catalogue was also prepared in manuscript. Both these lists are still in my possession after having been sent to many different botanists and returned by them. They are also in Mrs. Ward's handwriting and very plainly written indeed. The desiderata are of course given by names, and as fast as received the names were crossed off in red ink. The duplicates are numbers only, and these were crossed off when exhausted.

Equipped with all these documents as aids, I began early in 1877 an extensive system of exchanges and kept it up without serious interruption during the greater part of 1877, 1878, and 1879. By this time my collection was much more than doubled. I was also very active during these years in perfecting my local collections, and had far outstripped the new *Flora Columbiana*. But I did not say much about this to the other botanists, because by this time I was seriously contemplat-

ing a catalogue of my own. My exchanges were completed in March, 1880, and I did not make many additions to the flora during the season of that year. I went out many times but rarely found a a new plant.

By September, 1880, I was fully resolved to prepare a new catalogue. I secured some large cards of uniform size and gave them to Mrs. Ward to make first a card catalogue of all the plants of the Washington Flora. Then I arranged these cards in systematic order and commenced the work of transferring to them from my note-books all the data that I thought a catalogue should contain. This was a prolonged labor. The work of appending the notes to the cards was begun November 28, 1880. It was interrupted to make a systematic examination of Brereton's *Prodromus*, a copy of which I purchased from Dr. A. S. Foote of Philadelphia in October. I commenced this examination on December 28th and made thorough work of it. The results are summed up in Chapter III (pp. 11–17) of the *Introduction* to the *Flora*.

The beginning of 1881 saw me ready to commence writing the *Introduction* to my *Flora of Washington*. The title had already been decided upon, and is duly recorded in my note-book for November 28, 1880, in the same words as on the title-page. The work of reducing all the matter on the cards to manuscript form was begun by Mrs. Ward on January 5, 1881, so that both parts of the work were going on at the same time. I finished modernizing the *Prodromus* early in Jan-

uary, and proposed to present the matter to the Biological Society of Washington. The title of my paper was: "The Flora Columbiana of 1830 and 1880." It was read January 14, 1881. On January 22d I laid the whole subject before the Philosophical Society of Washington under another title (see *supra*, No. 116), and for the first time revealed to the astonished botanists the nature of my work during the past four years. Professor Chickering preceded me with a paper on the flora of Roan Mountain, North Carolina, and several other botanists were present. I had with me all the manuscript of both the *Introduction* and the *Catalogue* part, making a big show. That the botanists were chagrined was evident, but they all felt that at last we had something worth while. There was considerable discussion of minor points lasting till time for adjournment. I walked to the car with Professor Chickering, but he was silent on the main point. The feeling clearly was that an amateur had stepped in where the older botanists should have entered, and had accomplished what ought to have been done by them. But they had not done it. I had waited over three years since the appearance of the *Flora Columbiana*, and struggled in my exchanges with that defective work, and I saw exactly what was needed. Then I concluded to supply the need myself.

I went on with my work on the final paper, and on February 6th I finished writing the *Introduction*. I revised it carefully, and on the 13th I pronounced it done. On the 15th, I commenced writing the

Appendix, "Suggestions to Beginners," which was finished on the 20th, and revised on the two following days, but on the 28th I made some additions and supplied some omissions, completing it as it now stands. On March 9th, Mrs. Ward finished the manuscript of the catalogue proper, transferred from the cards. This was all carefully compared by us both, and finished on the 12th. On the 18th, 19th, and 20th, I compiled the *Summary* to follow the catalogue (pp. 145–147). This I then regarded as the last act, and considered the work finished.

On March 28, 1881, I called on Mr. J. Ormond Wilson, Superintendent of the Public Schools, whom I had long known, and told him about the work. He was much interested, and said the Normal Schools wanted just such a work. He asked me to show him the manuscript and I went and brought it to him. He was enthusiastic, and offered to see Professor Baird and urge its immediate publication by the Smithsonian Institution. Whether he did so or not I never learned, but think he did from the events that soon followed.

On April 8 (1881) I had a conversation on the subject with Prof. G. Brown Goode, Assistant Secretary of the Smithsonian Institution in charge of the National Museum, and he expressed himself favorable to the publication of my Catalogue by the Museum. On the 18th I called on Professor Baird and laid the whole matter before him. He was strongly in favor of its publication, and only feared that it could not be done by the appropria-

tions for the current year. On the 25th I prepared the table of contents. I also spent some time the next few days improving the *Introduction*, summarizing the several catalogues of other localities, etc. The final table on page 44 was prepared at that time, and the discussion on the next three pages was finished on May 5th. It was on that day that Professor Baird asked me again about it, and I took the manuscript over to his house, but he was not in when I called. On May 6th I laid my results before the Biological Society of Washington, the title of my paper being, "A Statistical View of the Flora of the District of Columbia." It dealt chiefly with the numerical comparisons between the District flora and those of other localities. On May 7th Dr. Foreman gave me the list of *Characeæ* to be included in my *Flora* (see pp. 10, 144). On the 23d Professor Baird called on me and informed me that he had received the order for printing my *Flora*, and later in the day he sent me the manuscript which was in his possession, and asked me to make any changes needed to bring it down to date. A number of points had arisen, and I proceeded to introduce the changes, including the *Characeæ*. On the 25th I informed Professor Baird that the manuscript was ready. It was not called for, and I continued to tinker it in various ways till June 20th, when I took it over to Professor Baird and left it for publication. It was sent to the printer on the 22d. It was hurried up at the Government Printing Office, and on July 5th I was shown a sample page. Galley

proof began to come on the 13th and I read considerable of it before I left for the West on the 26th. It lay in abeyance the entire summer, but on October 13th work was resumed and proofs began to arrive again.

The question of a map had occupied me from the first, and Major Powell told me I ought to have one. I had learned of the Hopkins map of a radius of 15 miles around Washington, but did not know how to see a copy. On October 27th, 1881, Professor Chickering sent me the address of G. M. Hopkins, and I at once wrote to him. He replied that it was not issued separate from the larger atlas. I then (October 29th) wrote to Mr. Carpenter, County Surveyor, who replied November 1st, that he could make the map. This proved impracticable on account of the expense. After looking at Professor Chickering's map I decided to have it copied, or copy it myself. The Geological Survey ordered the Atlas on November 14th, and it was received on the 23d. I proceeded to trace it on muslin. It was practically done on December 11th, but of course required to be copied by a regular map-maker. Major Powell said this should be done by the Survey, and referred me on December 23d to Mr. Holmes. It was finally placed in the hands of an expert named Karl, who copied it and completed it on February 27, 1882.

Thus far the matter of a check-list had not been considered. The manuscript consisted of the *Introduction*, the annotated *Catalogue*, the *Sum-*

mary, and the *Appendix*. But it occurred to me that this would be inconvenient in making exchanges, and that there should be a simple list with numbers, and with the lines quite wide apart for notes, which could be carried in the field and used in making notes. It might be interleaved if any one wished. I think I suggested it to Professor Baird and he approved of it. As the printers were nearing the end of the *Catalogue* about the first of November, 1881, I set about preparing this *Check List*. It went off rapidly, and by November 19th I had completed it. But the printers were upon me, and I took them all I had done on the 11th, and the balance as soon as done, so that the work was not interrupted at all by it.

The letter press in page form was well advanced on November 22, 1881, and I commenced preparing the index. It was completed December 21, 1881, and put in type in January, 1882, the last page arriving on the 31st. Some copies of the work were issued without the map on March 14th, but they were not accepted, and it did not properly appear till April 12th. On February 9th Professor Baird asked me if I wanted a private edition to sell. The official title-page could be omitted. I would only have to pay cost of press work plus 10 per cent. I saw Mr. Anglim, a bookseller, about it, and there was some negotiation. It was arranged to have 275 such copies printed. Later on it was decided to sell only bound copies, and on May 10th an agreement to that effect was signed by Mr. Anglim and myself. I waited

for months in expectation that the copies would be sent to me, and was ready to pay for them, but for some reason they never came, and the whole arrangement fell through.

It had been thought best to issue both the *Appendix* and the *Check List* as separate publications. The Institution had commenced the publication of a series of pamphlets giving directions how to collect and preserve specimens of natural history, but no such work had been prepared for plants, and Professor Baird thought best to issue my *Appendix* separately as a contribution to that series. Accordingly a title-page and cover were added and a new title given to this part. As already stated, the *Check List* was an afterthought, and this too was given a special title-page and cover. An edition of both was printed, but they appeared some months after the Bulletin, and bear date, 1882. All the publications of the Smithsonian Institution are numbered, and my *Guide* received the number 444, but for some reason this is not printed on the title-page and cover. The *Appendix* is No. 460, and the *Check List*, 461. The following is the lettering on the title-pages and covers of these two documents:

—460—
Directions
for
Collecting and Preserving
Plants.
By
Lester F. Ward.
From Bulletin of the United States National Museum, No. 22.
Washington:

Published by the Smithsonian Institution.
1882.

—461—
Check List.
Flora
of
Washington, D.C., and Vicinity.
By
Lester F. Ward.
From Bulletin of the United States National Museum, No. 22.
Washington:
Published by the Smithsonian Institution.
1882.

The numbers 460 and 461 appear on the cover and special title-page of the reprints, and nowhere else. The *Check List* contains pages 148 to 207, and the other pamphlet pages 209 to 237.

The Smithsonian Institution received 1500 copies of the Bulletin, but 275 of these were bound in cloth. I was allowed as many copies of all three of the documents as I wished to distribute, and they were sent out under frank. I distributed a great many, much more than of any other publication of mine before or since. I have a large package of the slips containing the names and addresses of those to whom I sent them. This package is separate from my regular mailing list. About every botanist in the country received a copy.

On April 20, 1882, the *Washington Post* contained a very nice notice of the work. It proved to be from the pen of Mr. Henry L. West, City Editor, whose acquaintance I made soon after, and with whom I have since made many

an interesting excursion. He deservedly rose to be one of the Commissioners of the District of Columbia.

There will be found in some copies a page containing "Additions and Corrections." These were prepared December 21–24, 1881, and the proof was corrected February 4, 1882. This page belongs at the end of the text as page 238, and the names occurring on it will be found in the index with reference to p. 238. In all the copies I have seen containing it at all it is made to follow the index, but it is apparently omitted from all the bound copies, and most of the others seem to be without it. It relates mostly to localities, and adds one species only, the tansy, collected by Mr. John M. Comstock and myself on Nichols Avenue, near the Government Hospital for the Insane, on July 26, 1879, but identified much later.

Six successive lists of additions to the Flora of Washington appeared after this work came out. The first was by myself (see *infra*, No. **171**, p.), extending to April 1, 1884; the second by Dr. F. H. Knowlton, extending to April 1, 1886; the third, fourth, and fifth, by Mr. Theodor Holm, extending to April 1, 1901, and the sixth by Mr. Edward S. Steele, published June 19, 1901, but containing the results of five years of investigation, quite independent of the other writers. Some species have been added even since that date, one certainly by myself. After the third list the flora aggregated 1667, as I find by a memorandum.

It must closely approach 2000 of the classes embraced in these lists.

But for the circumstance that this work appeared four months after the fascicle of the *Bulletin of the Philosophical Society* containing my *Field and Closet Notes on the Flora of Washington and Vicinity* was distributed, constituting publication, this would have been the proper place to mention my recommendation that the Rock Creek Region be set apart as a National Park (pp. 19–20), which has in fact been done.—See No. **116,** at end of sketch.

Department of the Interior: U. S. National Museum. —26— Bulletin of the United States National Museum. No. 22. Published under the Direction of the Smithsonian Institution. Washington: Government Printing Office. 1881.

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